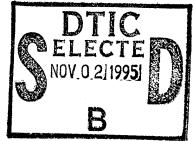
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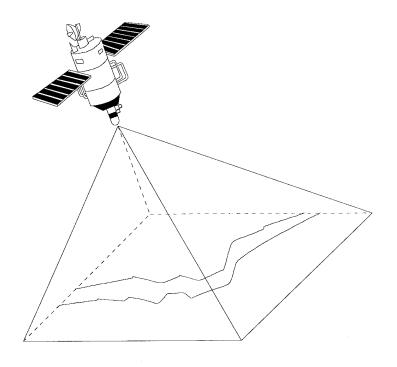


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A Comparison of the Performance of Non-Parametric Classifiers with Gaussian Maximum Likelihood for the Classification of Multispectral Remotely Sensed Data



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A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in the Center for Imaging in the College of Imaging Arts and Sciences of the Rochester Institute of Technology

Dr. John Schott, Thesis Advisor Dr. Peter Anderson, Committee Member Dr. Roger Easton, Committee Member Dr. Harvey Rhody, Committee Member

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by Steven W. Nessmiller B.S. United States Air Force Academy (1988)

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in the Center for Imaging Science Rochester Institute of Technology

September 1995

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A Comparison of the Performance of Non-Parametric Classifiers with Gaussian Maximum Likelihood for the Classification of Remotely Sensed Multispectral Data

by:

Steven W. Nessmiller

1.0 Abstract

This study compares the performance of two non-parametric classifiers and Gaussian Maximum Likelihood (GML) for the classification of LANDSAT TM 30-meter resolution six-band data. The mathematical assumptions made in developing GML are valid if the pixels that constitute the training classes are normally distributed. Since it requires a model of the data, GML is termed a "parametric" classifier. Of current interest are new classification methodologies that make no assumptions about the statistical distribution of the pixels in the training class; these approaches are termed "non-parametric" classifiers. This study will compare the n-Dimensional Probability Density Function (nPDF) essentially a projection technique that reduces data dimensionality, and an advanced neural network that utilizes fuzzy-set mathematics, the Fuzzy ARTMAP, to the traditional GML approach to image classification. The different approaches will be compared for statistical classification accuracy and computational efficiency.

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Dedication

First, this thesis is dedicated to the people who have had the greatest impact on my life, my parents. I think that all of the Lego, the Erector set, and the collection of "How and Why" books may have finally paid for themselves. I promise to keep doing my best.

Next, it is dedicated to the vast number of instructors who have taken the time, effort, and interest necessary to expertly instruct a wide array of subjects. I am proud to say that my sister is among your ranks continuing this critical profession.

Finally, this study is dedicated to the reader.

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2.0 Introduction

The objective of this thesis is to compare the performance of two non-parametric classifiers (a fuzzy ARTMAP neural network and the nPDF algorithm) with the classical Gaussian maximum likelihood (GML) approach. All parametric classification schemes, including GML, make some assumption about the statistical distribution of the training-class pixel intensity vectors. This assumption is utilized to determine a statistical decision rule (i.e. the Mahalanobis distance) for classification purposes. The GML has been shown to be a robust classifier, but its effectiveness suffers when the training-class pixel distribution varies markedly from normality or when class means are only slightly separated (Frey, 1994). Non-parametric classifiers make no assumption of the distribution of the pixels in the training classes. As such, they exhibit increased accuracy, but are extremely sensitive to biased training sets.

Four multispectral images of varying composition (i.e. agricultural, rural, urban, and forest) will be classified with the same training data by each algorithm. Four images will be classified by each algorithm to minimize the potential of anomalous effects arising from a particular image and algorithm combination.

The LANDSAT satellite collects multispectral information as it orbits above the earth's surface. The images collected by this system are composed of pixels that nominally represent the irradiance gathered from a 30-meter-square patch of the earth's surface. Each pixel in an image can be described by a six-dimensional intensity vector whose elements are the 8-bit digital count (DC) value (an integer ranging from 0 to 255). The spectral sensitivity of each band is summarized in table 2.0.1 (Richards, 1993). Note that band 6, the thermal band, is not included. This is due to the fact that this information is not correlated with that in the other bands. As such, it typically is not utilized in image classification operations.

Table 2.0.1 - Spectral sensitivity of LANDSAT TM bands

TM Band	Bandpass (µm)	"Color"
1	0.45 - 0.52	blue
2	0.52 - 0.60	green
3	0.63 - 0.69	red
4	0.76 - 0.90	near IR
5	1.55 - 1.75	mid IR
7	2.08 - 2.35	mid IR

Similarly, the M-7 airborne system is another multispectral sensor. It utilizes a line scanning system and can measure light at wavelengths in the range of 0.33 to 14.0 μm . Up to 19 different bands in this range can be collected simultaneously, with a typical ground sample distance of approximately 5 meters. Table 2.0.2 details the selected bands utilized in this study to mimic the LANDSAT TM sensor.

Table 2.0.2 - Spectral sensitivity of selected M-7 Bands

M-7 Band	Bandpass (µm)	"Color"
3	0.44 - 0.46	blue
6	0.52 - 0.55	green
8	0.60 - 0.67	red
10	0.83 - 1.00	near IR
12	1.50 - 1.90	mid IR
13	2.10 - 2.60	mid IR

The importance of high-quality training data cannot be overstated, especially for the non-parametric classifiers. By using the same training data for each classification algorithm, the potentially negative effects of any variation will be eliminated. The

distance separating the cluster centers of the target classes will be decreased to evaluate the impact of decreased separation on the effectiveness of each algorithm. Additionally, a hybrid classification approach which combines the strengths of the different algorithms will also be studied.

The different approaches to classification were compared statistically in terms of their classification accuracy via a confusion matrix and the kappa coefficient.

Computational efficiency was compared in terms of elapsed run time, training time, and system resource requirements. This comparison highlights the relative strengths and weaknesses of the different classifiers and determine the set of conditions where a specific classifier is best employed.

3.0 Objectives and Deliverables

Statement of Work

- Implement the various classifiers in the Advanced Visualization System (AVS), an interactive data visualization environment.
- Select at least four multispectral images of varying composition.
- Utilize the fuzzy K-means algorithm to collect trusted and spectrally pure training data for the classification algorithms.
- Utilize an AVS module to collect user-defined training data for the classification algorithms.
- Evaluate the classification algorithms statistically in terms of their classification accuracy on both dependent and independent training sets.
- Evaluate the classification algorithms computationally in terms of their efficiency.
- Experiment with hybrid classification methodologies.

List of Deliverables:

- A Gaussian maximum likelihood classification module for AVS environment.
- An AVS module to perform fuzzy K-means clustering to create truth images and collect trusted training data.
- An nPDF classification and module for LANDSAT TM images for use in the AVS environment that will permit user definable classification boundaries.
- An AVS module that implements the fuzzy ARTMAP neural network algorithm to classify LANDSAT TM images.
- An AVS module to compute confusion matrices and classification accuracy statistics.
- A written document covering the theory, background, approach, and results of the study.

4.0 Background and Approach

4.1 Acquisition of Training Data

The importance of high-quality training data in the parametric and non-parametric classification algorithms has been introduced. The various classification algorithms require labeled training data to calculate representative statistics, to train a neural network, or to define classification boundaries. The method in which these data will be acquired from each image bears some explanation. Consider the simplified representation of a LANDSAT TM scene (Figure 4.1.1) in the following discussion. We

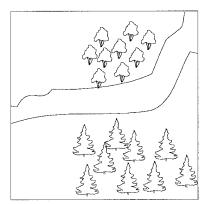


Figure 4.1.1 - Depiction of a LANDSAT TM scene

will assume that there are four classes of interest: coniferous trees, deciduous trees, water, and grass. The Gaussian maximum likelihood (GML) parametric classifier assumes that the training-class pixels are distributed in a multivariate normal manner. This assumption can be validated through application of the central limit theorem, but this theorem also imposes a restriction on the minimum number of pixels that must be present in each training class. Swain and Davis (1978) state that the minimum number of pixels per

training class is 10D, where D is the number of bands or dimensions being utilized in the classification algorithm, while 100D would be "highly desirable". Other references state that 30 examples per class produce results that are "quite good" for a one-dimensional or single-band case (Dougherty, 1990). The increase in the number of training-class pixels required to describe a class in a feature space of higher dimensionality can be intuitively explained quite readily. As dimensionality increases, the probability of a particular spectral band being inadequately represented also increases. To offset this, training class size must be positively correlated with dimensionality.

Because non-parametric classifiers make no assumption of the underlying statistical distribution of the pixels, no mathematical inference of class membership may be made. Because of this limitation, non-parametric algorithms require even more robust training data than the parametric classifiers. With these considerations in mind, this study will limit training class membership to not less than 30D and will strive for 100D whenever possible. In addition, all algorithms will use the same training data to classify each image, thereby eliminating any potential effects due to variations in training data.

Typically, training sets are defined by drawing polygons on the image that delineate the extent of a target class. Figure 4.1.2, is identical to Figure 4.1.1 except for of the superimposed training class polygons. Class 1 represents deciduous trees, class 2 is composed of coniferous trees, class 3 is comprised of water, and class 4 is made up of grass pixels. Note that in this example there were not enough contiguous grass pixels in one region to adequately describe the grass class. Because of this, two regions had to be defined to meet the previously discussed minimum membership criteria. The algorithm then extracts the pixels within the polygon and "labels" them as belonging to the indicated target class. The classification algorithms can then be presented with a set of

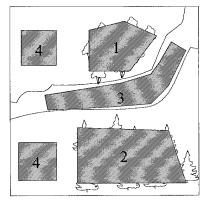


Figure 4.1.2 - Depiction of LANDSAT TM scene with overlayed training class polygons

labeled training data for each target class so that statistical or other calculations can be made.

The preceding discussion describes the most common method to collect training data for *supervised* classification algorithms. The term "supervised" implies that a human operator specifies the class membership of the test pixels. One of the main shortcomings of this process is that it is extremely difficult, if not impossible, to collect sets of "pure" training data. This difficulty springs from the inability to collect and label pixels that belong to only one spectral class. To envision this problem, consider the areas of the LANDSAT TM image depicted in figure 4.1.1 that are primarily composed of deciduous and coniferous trees. It would be extremely difficult to draw polygons that encompassed just tree pixels without accidentally including some of the background grass pixels. Training sets will likely always be "polluted" with such impurities.

Unsupervised image classification techniques often rely on information gathered from determining centers of clusters belonging to naturally occurring classes of spectral vectors in the image. To continue with the simplistic LANDSAT image example, it would be reasonable to assume that there are 4 major clusters of spectral vectors, one for each of the broad classes. A clustering algorithm typically determines the location of the cluster centers in pixel space in an iterative manner. Once the location of the clusters have been determined, some type of minimum-distance-to-the-means classification can be readily accomplished. This simple classification algorithm determines the Euclidean distance of the intensity vector of a pixel to the various cluster centers, and then assigns the pixel to the closest class. This set of spectrally pure and labeled pixels could provide an excellent data set to train the supervised classification algorithms.

The ISODATA, or K-means algorithm is a well known method of determining cluster centers. The parameter "K" represents the number of cluster centers to locate. The algorithm was developed by G. H. Ball and D. J. Hall in 1967 and is implemented in

many multispectral image processing packages. In 1973, J. C. Dunn developed a version of the algorithm which employed *fuzzy set theory* to determine the degree of membership of a spectral vector to a given cluster. This version generally converges faster and is less likely to divide naturally occurring clusters, than the crisp set theory implementation. The simplest explanation for the desirable qualities of this algorithm is that individual pixels need not be modeled as belonging to a cluster, but the degree of their *membership* can be determined. Pixels with high membership values greatly influence the cluster center, while outlying pixels with lower membership values influence it to a lesser degree. The mathematical development presented here essentially follows that in Dunn (1973).

Fuzzy set theory, to be described in greater detail in the section 4.4 of this report detailing the fuzzy ARTMAP neural network, is often "injected" into existing algorithms by implementing a *membership function*. This function returns a value which represents the degree to which a given data point belongs to a set. Large membership values, typically thresholded to unity, indicate that the pixel intensity vector displays many of the qualities of the set to a great degree. Lower values, typically closer to zero, indicate that the particular example does not fully represent all qualities of the set. Membership values are analogous to probabilities, but have different underlying mathematical properties and cannot be treated in the same manner. The great strength that this type of fuzzy measurement brings to an algorithm is that data elements can contribute to multiple sets rather than to the membership of only one set. Consider the representation of the boundary between neighboring sets. In one case the sets have crisp boundaries; in the other, the boundaries are fuzzy (Figure 4.1.3).

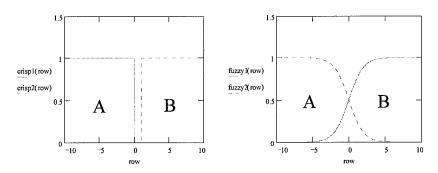


Figure 4.1.3 - Depiction of the boundary between two crisp sets (A and B at left) and the boundary defined by the membership function between two fuzzy sets (right).

The vertical axis of each plot represents the membership that a given point has in set A or set B. For the crisp set case, this value can be either 0 or 1, while the points belonging to the fuzzy set can have membership values anywhere in the unit interval. To see the power of a fuzzy set representation, consider the pixel located at x = +2. In the crisp set representation, the only information we have concerning this data point is that it has membership in set B. No knowledge about the strength of its membership, or the fact that it is located near a boundary, is conveyed. In the fuzzy-set view of the same data point (Figure 4.1.4), we see that this data point has strong membership (0.9) in set B, but

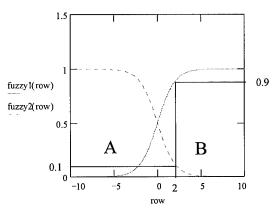


Figure 4.1.4 - Depiction of the membership of a point in two neighboring fuzzy sets

that it also has some of the qualities (0.1) of the data points that constitute set A. The information conveyed through the membership function allows us to treat this data point more appropriately. Whenever a decision is made to assign a data point to a particular set, some information is lost. Fuzzy-set theory combats this

information loss by relaying a confidence measure about the quality or strength of the decision.

At the start of the fuzzy clustering algorithm, the number K of clusters to be found must be estimated. This can be approximated by visually inspecting the image, or set based on a priori knowledge of how many classes are necessary. Many non-trivial papers are devoted to intelligent determination of the number of clusters present in a data set, but further discussion of this subject is beyond the scope of this report. After a value for K is selected, that K pixels are chosen at random from the input image. This ensures that the algorithm is starting with valid solution positions and is not outside the solution space. Another way to begin the algorithm would be to determine the minimum and maximum spectral intensity vectors across all bands, and then construct a line in the N-dimensional space (where N represents the number of data bands) with K evenly spaced points as initial solutions. The membership with respect to each of the K clusters is then determined. Consider the following membership equation:

$$m_{i}(\overline{\mathbf{x}}) = \frac{\frac{1}{(\overline{\mathbf{x}} - \overline{\mathbf{u}}_{i})^{2}}}{\sum_{j=1}^{k} \left(\frac{1}{(\overline{\mathbf{x}} - \overline{\mathbf{u}}_{j})^{2}}\right)}$$
 for $1 \le i \le k$ (4.1.1)

where $\bar{\mathbf{x}}$ is the N-dimensional spectral vector for a given pixel, $\bar{\mathbf{u}}_i$ is the spectral vector representing the center of the "*i*th" cluster, and $m_i(\bar{\mathbf{x}})$ is the membership of the pixel with respect to the *i*th cluster. The distance measure employed in this implementation should be recognized as the square of the simple Euclidean distance. Note that the membership equation approaches unity for points near to one class and far from all others. Numerical problems associated with being very close (or directly on) a cluster center are handled by checking for very small distance measures and then setting the membership of the pixel to that cluster to one. Once the membership of the pixels in the image have been

determined with respect to each cluster, the new cluster centers can be calculated. Consider the following equation:

$$\overline{\mathbf{u}}_{i} = \frac{\sum_{x \in \chi} \left[m_{i}(\overline{\mathbf{x}}) \right]^{2} \overline{\mathbf{x}}}{\sum_{x \in \gamma} \left[m_{i}(\overline{\mathbf{x}}) \right]^{2}} \qquad \text{for } 1 \le i \le k$$
 (4.1.2)

where $x \in \chi$ implies that the sum is taken over all the pixels in the image. Note that this equation must be calculated K times to find the elements of $\bar{\mathbf{u}}_i$. This forms a weighted average of the influence of each pixel on each cluster center through the use of the membership function. Once the new cluster centers have been calculated, the distance that the center vectors have moved since the last iteration is determined. If the maximum movement is below some user-defined threshold, we can conclude that the cluster centers have converged to their final locations. After the cluster centers have converged, the "cluster map" image is constructed by checking the membership value of each pixel in the image with respect to all of the clusters. If the largest membership value is equal to or greater than a user-defined membership threshold, the pixel is "labeled" as part of that class. A set of training data can then be built by scanning the cluster map image for pixels assigned to clusters, retrieving the corresponding multispectral pixel from the original image, sorting them by cluster number, and writing the resulting ordered set to disk. In pseudocode, the entire fuzzy K-means algorithm can be expressed as:

pick K clusters at random from the image
while clusters have not converged
calculate membership
calculate new cluster centers
check for convergence
build cluster map
build training set

It is important to note that while we have constructed a set of labeled spectrally pure pixels for a data set, that we have potentially "colored" them by the collection

methodology. We have employed a Euclidean distance measure that we will later see is unable to account for a data set's inherent distribution. Also note that the algorithm may not find clusters in the image of interest to the analyst, and, furthermore, it may then be difficult for the analyst to assign meaningful labels to each of the derived clusters.

Image Classification Algorithms

4.2 Gaussian Maximum Likelihood

Gaussian Maximum Likelihood (GML) is perhaps the most popular classification algorithm due to its employment of classical mathematics and the fact that it generates a measurement of membership certainty of a pixel to a class. GML is widely taught in introductory courses in both remote sensing and pattern recognition, and it is implemented in many image processing packages. As such, it is a standard to which the performance of other algorithms can be compared.

GML is a parametric classifier, based on the assumption of normally distributed pixel intensity vectors. It has been shown that the assumption of normally distributed pixel intensity vectors is valid in a typical remote sensing application (Frey, 1994). This can be attributed to the averaging effect of the LANDSAT TM sensor as it detects the irradiance emitted or reflected from a nominally 30-meter square patch on the earth. Recall that the density of the sum of two independent random variables is the convolution of their individual densities. The averaging of the TM sensor essentially convolves the probability density functions of the materials from which the detected photons were emitted or reflected. Repeated convolution of the individual probability density functions rapidly approaches a normal distribution. This is the basis for the central limit theorem. Nevertheless, the GML algorithm has also been shown to be extremely robust, even when dealing with data sets that deviate markedly from normality (Frey, 1994). The development presented here essentially follows that in Richards (1993), with the link to the χ^2 (chi squared) distribution developed by Johnson and Wichern (1992).

4.2 Mathematical Development of GML

In the development of the algorithm we will assume that the components of the n-dimensional vector $\bar{\mathbf{x}}$ represent the intensity vector of a pixel, and the m-dimensional vector $\bar{\mathbf{w}}$ represents the target classification classes.

$$\bar{\mathbf{x}} = \begin{pmatrix} x_1 \\ x_2 \\ \vdots \\ \vdots \\ x_n \end{pmatrix} \qquad \bar{\mathbf{w}} = \begin{pmatrix} w_1 \\ w_2 \\ \vdots \\ \vdots \\ w_m \end{pmatrix}$$

From the training data, we can calculate the following conditional probability,

$$p(\bar{\mathbf{x}}|w_i) \tag{4.2.1}$$

which should be interpreted as the probability that a pixel with spectral vector $\bar{\mathbf{x}}$, is a member of class w_i . A much more useful measure to develop would be:

$$p(w_i|\bar{\mathbf{x}}) \tag{4.2.2}$$

which is the probability of membership in class w_i for a specific pixel. This measure could be utilized for classification by determining the most probable class for a pixel. This measure can be derived through the application of Bayes' Rule which can be stated as:

$$p(a|b) = \frac{p(a \cap b)}{p(b)} \tag{4.2.3}$$

similarly,
$$p(b|a) = \frac{p(b \cap a)}{p(a)} = \frac{p(a \cap b)}{p(a)}$$
 (4.2.4)

where the \cap operator indicates simple intersection of two sets. By setting the equivalent terms equal and regrouping, we can state:

$$p(b|a) = \frac{p(b)p(a|b)}{p(a)}$$
 (4.2.5)

In our previous notation, a useful result is obtained:

$$p(w_i|\bar{\mathbf{x}}) = \frac{p(w_i)p(\bar{\mathbf{x}}|w_i)}{p(\bar{\mathbf{x}})}$$
(4.2.6)

Two terms in equation 4.2.6 require some clarification. The term $p(w_i)$ often is titled an a prior probability as it acts as a weighting function which reflects how much of a given image is composed of a particular class. This term normally is set equal to 1/M, where M is the number of classes. When this condition is obviously not true, the term will be reasonably estimated. The $p(\overline{\mathbf{x}})$ term represents the probability of a pixel with spectral vector $\overline{\mathbf{x}}$ being present in the image. Note that pixels are classified by comparing the various conditional probabilities of each spectral intensity vector for each target classification class. When utilizing this methodology, the term $p(\overline{\mathbf{x}})$ will appear in the denominator of both conditional probabilities on both sides of the inequality. Since it is a common term, it can be canceled. This results in the following classification logic:

$$\bar{\mathbf{x}} \in w_i \text{ if } p(w_i | \bar{\mathbf{x}}) > p(w_i | \bar{\mathbf{x}}) \text{ for all } i \neq j$$
 (4.2.7)

It is important to realize that equation 4.2.7 states that all spectral vectors present in the image will be assigned to one of the target classes in the image. This may not be desirable, and the requirement can be eliminated by setting a threshold for class membership assigning a pixel whose probability is less than the threshold to a "background" class.

If we now assume that the spectral intensity vectors are distributed in a multivariate normal manner the conditional probability can be stated in the following manner:

$$p(\bar{\mathbf{x}}|w_i) = \frac{1}{(2\pi)^{\frac{D}{2}} \sqrt{|\Sigma_i|}} e^{-\frac{1}{2}(\bar{\mathbf{x}} - \bar{\mu}_i)^T \sum_i^{-1} (\bar{\mathbf{x}} - \bar{\mu}_i)}$$
(4.2.8)

Where Σ_i^{-1} is the inverse of the *variance-covariance* matrix for class i, $\bar{\mu}_i$ is the mean vector for the "ith" class, $\bar{\mathbf{x}}$ is the spectral intensity vector whose class membership is being evaluated, and D is the number of dimensions or spectral bands being used. The operator "| |" designates matrix determinant and the transpose operator "T" converts the column vectors to row vectors and vice versa. The variance-covariance matrix contains a wealth of information concerning the dispersion of data in a target class. As such, it

warrants some explanation. The general form of a variance-covariance matrix is:

Figure 4.2.1 - general form of Σ matrix

where σ_{ij}^2 is the covariance of band i with respect to band j. The matrix can be calculated by:

$$\Sigma_i = \varepsilon \{ (\bar{\mathbf{x}} - \bar{\mu}_i) (\bar{\mathbf{x}} - \bar{\mu}_i)^T \}$$
 (4.2.9)

Where ε is the expectation operator. Typically an unbiased estimator is utilized to approximate the variance-covariance matrix numerically:

$$\Sigma_{i} = \frac{1}{K-1} \sum_{i=1}^{K} (\bar{\mathbf{x}} - \bar{\mu}_{i}) (\bar{\mathbf{x}} - \bar{\mu}_{i})^{T}$$
(4.2.10)

where K represents the number of data elements in the training class. It is important to realize that this calculation must be performed once for each of m classes, so that all the target classification classes are described mathematically. Also realize that σ_{ij}^2 must equal σ_{ji}^2 , and that σ_{ij}^2 is the simple empirical variance. In general, if any of the off-diagonal terms (σ_{ij}^2) have large amplitudes, bands i and j are highly correlated. This implies that information about one band can be used to predict the value of another, or that the information contained within the bands is not independent, but correlated. More simply put, if bands i and j are positively correlated, an increase in band i will be accompanied by a corresponding increase in the observed values in band j. If the off-diagonal values are small, then the data are independent and cannot be described by some linear combination of the spectral bands. As previously mentioned, the information contained within the variance-covariance matrix permits more accurate modeling of the dispersion of the data that constitutes a training class. Specifically, the information

contained within a variance-covariance matrix defines an n-dimensional hyperellipsoid in feature space. The eigenvalues of the matrix define the lengths of the axes of the hyperellipsoid, while the associated eigenvectors determine their orientation (Johnson and Wichern, 1992).

Returning to the development of GML, we will at this point introduce the *discriminant* function, which will result in some mathematical convenience:

$$g_i(\bar{\mathbf{x}}) \equiv \ln\{p(\bar{\mathbf{x}}|w_i)\}\tag{4.2.11}$$

and applying this operation to the multivariate normal distribution yields:

$$g_i(\bar{\mathbf{x}}) = -\frac{D}{2}\ln(2\pi) - \frac{1}{2}\ln|\Sigma_i| - \frac{1}{2}(\bar{\mathbf{x}} - \bar{\mu}_i)^T \Sigma_i^{-1}(\bar{\mathbf{x}} - \bar{\mu}_i)$$
(4.2.12)

Note that a number of common terms can be eliminated in classification, resulting in a discriminant function that can be stated as:

$$g_i(\overline{\mathbf{x}}) = -\ln|\Sigma_i| - (\overline{\mathbf{x}} - \overline{\mu}_i)^T \Sigma_i^{-1} (\overline{\mathbf{x}} - \overline{\mu}_i)$$
(4.2.13)

Classification may be accomplished by employing the following rule:

$$\bar{\mathbf{x}} \in w_i \text{ if } g_i(\bar{\mathbf{x}}) < g_i(\bar{\mathbf{x}}) \text{ for all } i \neq j$$
 (4.2.14)

Note that the last term of equation 4.2.13 resemble a distance measure. By eliminating the negative signs and considering the special case where Σ_i is the identity matrix, the classification rule reduces to the simple Euclidean distance measure. This distance measure can be described mathematically as:

$$d_E(\bar{\mathbf{x}}, \bar{\mu}_i)^2 = (\bar{\mathbf{x}} - \bar{\mu}_i)^T (\bar{\mathbf{x}} - \bar{\mu}_i)$$
(4.2.15)

and the classification rule becomes:

$$\bar{\mathbf{x}} \in w_i \text{ if } d_E(\bar{\mathbf{x}}, \bar{\mu}_i)^2 < d_E(\bar{\mathbf{x}}, \bar{\mu}_i)^2 \text{ for all } i \neq j$$
 (4.2.16)

In feature space, equation 4.2.16 defines a set of hyperspheres located concentrically about the mean vector of the class. This Euclidean distance measure is the heart of the minimum-distance-to-the-means classification methodology.

Incorporation of the data distribution information in the variance-covariance matrix into a distance measure can be accomplished quite readily. Consider the following

measure, often termed the Mahalanobis or statistical distance:

$$d_{M}(\overline{\mathbf{x}}, \overline{\mu}_{i})^{2} = \ln |\Sigma_{i}| + (\overline{\mathbf{x}} - \overline{\mu}_{i})^{T} \Sigma_{i}^{-1} (\overline{\mathbf{x}} - \overline{\mu}_{i})$$

$$(4.2.17)$$

A development identical to that leading to equation 4.2.14 results in the following classification rule:

$$\bar{\mathbf{x}} \in w_i \text{ if } d_M(\bar{\mathbf{x}}, \bar{\mu}_i)^2 < d_M(\bar{\mathbf{x}}, \bar{\mu}_j)^2 \text{ for all } i \neq j$$
 (4.2.18)

which represents the desired Gaussian maximum likelihood classifier. As compared to the previous Euclidean distance measure classifier (equation 4.2.16) note that this algorithm defines an n-dimensional hyperellipsoid in feature space. This is accomplished by the "space scaling" effect of the variance-covariance matrix.

It is generally desirable, though computationally intensive, to account for the dispersion of the training data. The validity of this statement can be visualized readily. Consider the identical two-dimensional feature spaces in figures 4.2.3a and 4.2.3b. The information about the covariance of the cluster is not utilized in the first example (Euclidean distance measure and minimum-distance-to-the-means), but is employed in the second case (Gaussian maximum likelihood employing the Mahalonobis distance). The pixel to be classified is represented by the cross near the middle of the feature space. In Figure 4.2.3a, the pixel of interest would be assigned to class one as its vector is closer to μ_1 in a Euclidean sense. By taking into account the inherent dispersion of the data, as

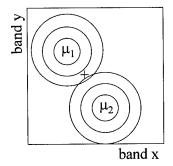


Figure 4.2.3a hyperspheres resulting from minimum distance to the means

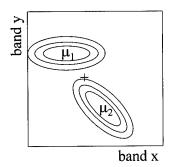


Figure 4.2.3b hyperellipsoids resulting from GML

depicted in Figure 4.2.3b, the GML classifier would assign the pixel to class two. Note that this effect is most easily explained by realizing that the information contained within the variance-covariance matrix essentially scales feature space differently in different directions thereby accounting for the data's dispersion.

As previously mentioned, Gaussian maximum likelihood always assigns a pixel to one of the target classification classes. This can be undesirable especially in the case where a particular pixel is below some threshold for membership in any target class, and it would be most advantageous to assign this pixel to a "background" or "other" class. Recall the Mahalanobis distance measure as defined in equation 4.2.17:

$$d_M(\overline{\mathbf{x}}, \overline{\mu}_i)^2 = \ln|\Sigma_i| + (\overline{\mathbf{x}} - \overline{\mu}_i)^T \Sigma_i^{-1} (\overline{\mathbf{x}} - \overline{\mu}_i)$$
and its associated algorification rule equation 4.2.18:

and its associated classification rule equation 4.2.18:

$$\bar{\mathbf{x}} \in w_i \text{ if } d_M(\bar{\mathbf{x}}, \bar{\mu}_i)^2 < d_M(\bar{\mathbf{x}}, \bar{\mu}_i)^2 \text{ for all } i \neq j$$
 (4.2.20)

We desire to incorporate a threshold value into this measure to describe the level of certainty to be attained prior to assigning a pixel to a given class. Mathematically, this can be expressed as:

$$\bar{\mathbf{x}} \in w_i \text{ if } d_M(\bar{\mathbf{x}}, \bar{\mu}_i)^2 < d_M(\bar{\mathbf{x}}, \bar{\mu}_j)^2 \text{ for all } i \neq j$$

and $d_M(\bar{\mathbf{x}}, \bar{\mu}_i)^2 \leq T_i$ (4.2.21)

where T_i is the threshold value to attain membership in class i. It can be shown (Johnson and Wichern, 1992) that for a *D*-dimensional multivariate normal distribution, the vectors have a χ^2 (chi squared) distribution if the hyperellipsoids of vectors satisfy the following relationship:

$$(\bar{\mathbf{x}} - \bar{\boldsymbol{\mu}}_i)^T \Sigma_i^{-1} (\bar{\mathbf{x}} - \bar{\boldsymbol{\mu}}_i) \le T_i \tag{4.2.22}$$

This distribution has D degrees of freedom and a probability of 1- α . In a more compact notation this is typically represented as $\chi^2_D(\alpha)$ Utilizing this result to our distance measure results in the following classification algorithm:

$$\bar{\mathbf{x}} \in w_i \text{ if } d_M(\bar{\mathbf{x}}, \bar{\mu}_i)^2 < d_M(\bar{\mathbf{x}}, \bar{\mu}_j)^2 \text{ for all } i \neq j$$

and $d_M(\bar{\mathbf{x}}, \bar{\mu}_i)^2 \le \chi_D^2(\alpha)$ (4.2.23)

Intuitively, equation 4.2.23 is comforting. As the value of α is decreased, thereby increasing the probability that a particular spectral intensity vector is within the hyperellipsoid of a given class, the $\chi_D^2(\alpha)$ distribution returns larger and larger values. This can be visualized as the hyperellipsoid swelling or inflating in feature space to encompass a greater and greater volume.

4.3 n-Dimensional Probability Density Functions (nPDF)

The nPDF algorithm was codeveloped at the Department of Earth and Atmospheric Sciences at Purdue University by Haluk Cetin and Donald W. Levandowski. This method utilizes what are known as *frequency perspective* plots to allow the display of multi-dimensional data on two-dimensional display devices (such as a CRT), to reduce data dimensionality in a manner similar to the Karhunen-Loe've transformation, to classify the multidimensional data in either a supervised or unsupervised manner, and to perform cluster analysis prior to classification. In essence, the algorithm projects n-dimensional data onto a two-dimensional plane through the use of two distance measurements. The straightforward mathematical development that follows will center on the derivation of the projection technique and how the resulting projection can be utilized for classification. The development presented here essentially follows that presented by Cetin and Levandowski (1991).

4.3.1 Mathematical Development of nPDF

As previously mentioned, the nPDF algorithm essentially projects n-dimensional data onto the two-dimensional plane where considerably simplified classification techniques can be applied. In a two-dimensional feature space, a feature vector is defined by:

$$\bar{\mathbf{x}} = \begin{pmatrix} x_1 \\ x_2 \end{pmatrix}$$

A simple way to uniquely describe the position of the point (x_1, x_2) in this feature space is as the intersection of two arcs originating from two reference points or "corners". Consider the diagram in Figure 4.3.2 where band 1 and band 2 are two bands of interest in the multispectral data. The range of the axes is assumed to be 256 (2^8 as per 8-bit TM data). The magnitudes of the radii of the arcs are:

$$d_1 = \sqrt{x_1^2 + x_2^2} \tag{4.3.1}$$

$$d_2 = \sqrt{(R - x_1)^2 + x_2^2}$$
 (4.3.2)

where R represents the maximum value of the data (255). By extending this concept to a three-dimensional feature space, Figure 4.3.2 is easily obtained.

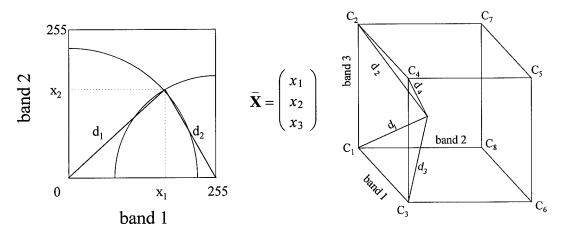


Figure 4.3.1 a two-dimensional feature space

Figure 4.3.2 three-dimensional vector and its feature space representation

As previously defined, the distances d_1 and d_2 , from corners C_1 and C_2 to the point of interest are:

$$d_1 = \sqrt{x_1^2 + x_2^2 + x_3^2} \tag{4.3.3}$$

$$d_2 = \sqrt{x_1^2 + x_2^2 + (R - x_3^2)} \tag{4.3.4}$$

Complimentary equations for the other distances from the other reference corners of the

feature space can be easily derived following this same process. This process may be extended to higher dimensions where the feature vector is:

$$\bar{\mathbf{X}} = \begin{pmatrix} x_1 \\ x_2 \\ \cdot \\ \cdot \\ \cdot \\ x_n \end{pmatrix}$$

and the distance measures can be generalized to:

$$d_{i} = \sqrt{\sum_{j=1}^{n} \left(x_{j}^{2} * a_{j} + (R - x_{j})^{2} * b_{j}\right)}$$
(4.3.5)

where i is the reference "corner number" of the hypercube, j is the band number, n is the number of bands, and a_j and b_j are values necessary to calculate the distances to the corners of the n-dimensional hypercube. The values of a_j and b_j necessary to calculate the d_1 through d_4 measurements on the LANDSAT TM six-dimensional data are summarized in table 4.3.1.

Table 4.3.1 - values of a_i and b_i

$\begin{array}{c ccccccccccccccccccccccccccccccccccc$,	,			
1 1 0 1 0 1 0 1 0 2 1 0 1 0 0 1 0 1		(d_1	d	\mathbb{I}_2	Ċ	l_3	d	4	
	TM Band	\mathbf{a}_{j}	\mathbf{b}_{j}	\mathbf{a}_{j}	b_j	\mathbf{a}_{j}	$\mathbf{b_{j}}$	$\mathbf{a}_{\mathbf{j}}$	\mathbf{b}_{j}	
	1	1	0	1	0	1	0	1	0	
3 1 0 0 1 1 0 0 1 4 1 0 1 0 1 0 1 0 5 1 0 1 0 0 1 0 1	2	1	0	1	0	0	1	0	1	
4 1 0 1 0 1 0 1 0 5 1 0 1 0 0 1 0 1	3	1	0	0	1	1	0	0	1	
5 1 0 1 0 0 1 0 1	4	1	0	1	0	1	0	1	0	
	5	1	0	1	0	0	1	0	1	
7 1 0 0 1 1 0 0 1	7	1	0	0	1	1	0	0	1	

With these distance measures developed, we are now ready to derive the rest of the nPDF components. Consider the following equation:

$$nPDF_i = S * \frac{d_i}{2^{BIT} \sqrt{NB}} \tag{4.3.6}$$

where d_i is the distance from the "*i*th" corner to the point of interest as previously defined, *BIT* is the number of bits in the input data (8 for LANDSAT TM), *NB* is the number of bands being utilized (6 for LANDSAT TM), and *S* is a scale factor. Note that the ratio term in equation 4.3.6 returns a value between zero and slightly less than one. Multiplication by the scale factor allows the frequency perspective plot to be stretched so that finer details in the plot may be observed. The nPDF components are utilized in pairs to produce the nPDF, or frequency perspective, plots. By our previous definitions, 6 plots are possible utilizing the different distance measures arising from the following unique combinations: C₁-C₂, C₁-C₃, C₁-C₄, C₂-C₃, C₂-C₄, and C₃-C₄. Utilization of different principal corner pairs produces differing nPDF plots. By choosing different corner pairs, the separation between desired target classes may be increased to yield increased classification accuracy.

To illustrate the procedure of creating the nPDF plot and the ensuing classification process, a synthetic 3-dimensional training set consisting of 4 normally distributed classes was created. The data set ranges in value from 0 to 31. As previously defined, R is set equal to 31, BIT is set equal to 5 (because $2^5 = 32$), NB = 3, and S = 64. The scale factor dictates the size of the resulting nPDF plot, and in this case, a 64-by-64 plot will be created. Because of this a 64-by-64 array must be allocated and initialized to contain all zeros prior to any further calculations. The nPDF plot is most simply considered to be a height field and the corresponding array will be referenced by height_field[row][col]. The following algorithm in pseudocode will produce an nPDF plot for the synthetic data set utilizing the d_1 and d_4 measurements:

next row

$$d_{1} = \sqrt{\sum_{j=1}^{3} \left(x_{j}^{2} * a_{1_{j}} + (R - x_{j})^{2} * b_{1_{j}}\right)}$$

$$d_{4} = \sqrt{\sum_{j=1}^{3} \left(x_{j}^{2} * a_{4_{j}} + (R - x_{j})^{2} * b_{4_{j}}\right)}$$

$$npdf_{1} = S * \frac{d_{1}}{2^{BIT} \sqrt{NB}}$$

$$npdf_{4} = S * \frac{d_{4}}{2^{BIT} \sqrt{NB}}$$

height_field[$npdf_1$][$npdf_4$] = height_field[$npdf_1$][$npdf_4$] + 1 next col

where a_j and b_j reference the components of the following vectors as defined in table 4.3.1:

$$\bar{a}_1 = \begin{pmatrix} 1 \\ 1 \\ 1 \end{pmatrix} \qquad \bar{b}_1 = \begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix} \qquad \bar{a}_4 = \begin{pmatrix} 1 \\ 0 \\ 0 \end{pmatrix} \qquad \bar{b}_4 = \begin{pmatrix} 0 \\ 1 \\ 1 \end{pmatrix}$$

Note that the algorithm essentially "counts up" the number of data elements (or pixels) in the training set that share the same $npdf_1$ and $npdf_4$ values and "bins" them together. This is accomplished by rounding off the calculated nPDF value to the nearest integer and using this value as the index for the height_field array which is then sequentially incremented. This process produces the height-field effect as previously discussed. The synthetic training data set was created with the four normally distributed classes, each with unit variance, and the following mean vectors:

$$\bar{m}_1 = \begin{pmatrix} 28 \\ 28 \\ 28 \end{pmatrix}$$
 $\bar{m}_2 = \begin{pmatrix} 4 \\ 4 \\ 4 \end{pmatrix}$ $\bar{m}_3 = \begin{pmatrix} 16 \\ 4 \\ 4 \end{pmatrix}$ $\bar{m}_4 = \begin{pmatrix} 20 \\ 20 \\ 10 \end{pmatrix}$

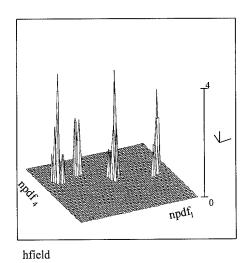
Table 4.3.2 lists the nPDF values for the mean vectors:

Table 4.3.2 - values of npdf₁ and npdf₄ for the synthetic data

class	npdf ₁	npdf ₄
1	56	33
2	8	44
3	20	48
4	35	36

We expect to see concentrations of pixels scattered around these coordinates in the nPDF plot. The height field and contour diagrams below were created by applying the nPDF algorithm to the synthetic data and utilizing the d_1 and d_4 measurements.

Examining the plots confirms the previous conjecture as spikes in the height field and "blobs" in the contour plot are located at the previously calculated nPDF coordinates for the centers of the training class distributions.



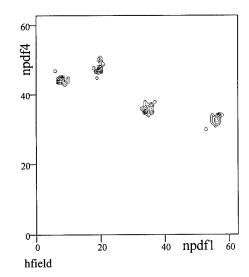


Figure 4.3.3 - nPDF height-field and contour plot

Once the location of the class mean vectors are calculated in the nPDF space, an image classification algorithm very similar to the minimum-distance-to-the-means can be easily developed. Consider the following image classifier logic:

$$\bar{\mathbf{x}} \in w_i \text{ if } d_{nPDF}(\bar{\mathbf{x}}, \bar{\mu}_i)^2 < d_{nPDF}(\bar{\mathbf{x}}, \bar{\mu}_j)^2 \text{ for all } i \neq j$$
 (4.3.7)

where $d_{nPDF}(\bar{\mathbf{x}}, \bar{\mu}_i)^2 = (\bar{\mathbf{x}} - \bar{\mu}_i)^T(\bar{\mathbf{x}} - \bar{\mu}_i)$. This is identical to the Euclidean distance measure, with the important exception that this calculation need be performed only in the two-dimensional nPDF feature space. While there is considerable computational savings in performing this measure in the space with reduced dimensionality, recall that the intensive projection calculations must be completed for every pixel in the image prior to its classification. As intuitively expected, the performance of this image classifier is very similar to the multidimensional minimum-distance-to-the-means algorithm, and is fraught with the same inability to account for data dispersion in the training classes.

After calculating the nPDF plot for the training classes, classification of the entire image can be accomplished in a unique manner. Consider the previously calculated contour plot that has been arbitrarily segmented as shown in Figure 4.3.4. The regions

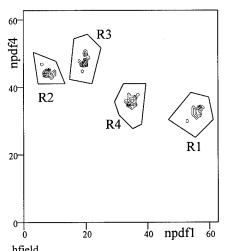


Figure 4.3.4 - nPDF contour plot with overlayed classification boundaries

marked R₁ through R₄ correspond to the previously defined target classes. This mapping can be utilized as a lookup table (LUT) if we fill the array elements corresponding to a particular polygon with the numerical value of that class (a 1, 2, 3, or 4 in this simple example). The npdf₁ and npdf₄ values are calculated for each pixel in the original image. With these values, we simply look up the target classification class value and assign the pixel to it.

This method of supervised classification, where a human specifies the classification boundaries in a projection of feature space, has some notable advantages. Foremost of these is that the classification performance depends entirely on the users selection of bounding polygons, which can be readily modified to account for subtle shape fluctuations in the data distribution that could be extremely difficult to model mathematically. Complicated and time consuming calculations of the multi-dimensional bounding volume or distance measures need not be completed as the simplified two-dimensional boundaries can be implemented as LUTs in the nPDF space. Also no difficult statistical calculations are required to determine if a pixel should be assigned to a "background" or "other" class as is necessary in GML classification. The most notable disadvantage of this method is the subjective placement of the boundaries which are difficult to reproduce accurately.

The nPDF algorithm also has considerable utility for estimating the number of target classes present in a data set. This information is very useful in cluster analysis, and

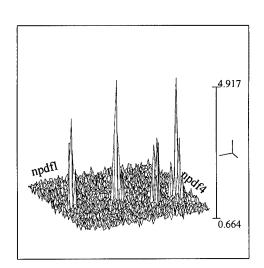


image hfield

Figure 4.3.5 - nPDF height-field plot of 4 clusters in the presence of noise

is at the heart of unsupervised classification methodologies. Illustrating this facet of the algorithm is also quite simple. If the nPDF plot is computed for the entire image, we would expect that masses of pixels with similar spectral intensity vectors would generate high peaks in the plot. By simply counting the number of these spikes, a reasonable estimate of the number of target classification classes K can be made. This process is illustrated in Figure 4.3.5, which was created by calculating an nPDF plot for an

"entire image" of the synthetic data set, to which some random "background" noise was added. The random noise appears as small data fluctuations at the base of the diagram while the four peaks represent the major data clusters in the data set.

4.4 Fuzzy ARTMAP Neural Network

A review of the current literature in the field of remote sensing will indicate that many neural-network architectures have been utilized for classifying image data. The chief advantage of utilizing neural networks for classification arises from the fact that a single flexible learning algorithm is able to derive an optimal decision rule for a given situation from the training data. The chief problems of this family of algorithms are long learning times and the inability to deal with "fuzzy" data. The term "fuzzy" relates the concept of the extent to which a given feature is present in an exemplar. Terms such as "close to home", "much greater than five", and "quite young", are linguistic examples that portray this concept. Human beings are naturally fuzzy in their decision-making processes. While it is quite simple for a graduate student to label a given instructor as a "good teacher", it has traditionally been impossible to provide a computer with the tools to make this same type of classification. Neural networks are typically implemented on general-purpose computer hardware and are hindered by their inherent binary nature. In the mid 1960's, L. A. Zadeh derived the mathematical groundwork for a field of study that would become known as fuzzy logic. Armed with these new tools, engineers and researchers have utilized these concepts to permit the machine computation of fuzzy data.

An advanced neural network, the fuzzy ARTMAP, attacks both traditional shortcomings of neural networks in a very direct manner. Conventional neural network methodologies typically require training data to be applied repeatedly, often thousands of times, to determine a set of decision rules that produce a desired level of performance. By comparison, the Adaptive Resonance Theory and MAPping (ARTMAP) approach can perform the same classification to the same level of accuracy after only a handful of training cycles, or epochs. The introduction of fuzzy logic to this family of algorithms greatly increases their flexibility because features that previously could only be said to be present or absent can now be more completely described. When dealing exclusively with

binary data, the algorithm reduces to its crisp set theory predecessors. The overview in section 4.4 essentially summarizes that of Carpenter *et al.*, (1992).

4.4 Overview of fuzzy ARTMAP Neural Network Architecture

Consider the overall system diagram for the neural network of interest:

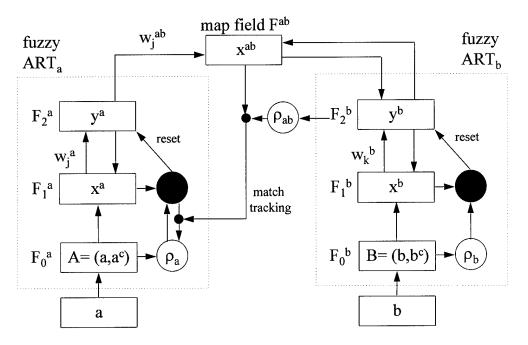


Figure 4.4.1 - Fuzzy ARTMAP Architecture

This neural network is not as complex as it may appear. The network must be trained before the LANDSAT TM images can be classified. This is accomplished by applying the spectral intensity vectors of the training-class pixels at point \mathbf{a} , while the corresponding label or target class will be applied simultaneously at point \mathbf{b} . An important calculation, known as *complement coding*, takes place on the input data in the *preprocessing fields* $\mathbf{F_0}^{\mathbf{a}}$ and $\mathbf{F_0}^{\mathbf{b}}$. Initially the input data, (represented here as the vector \mathbf{I}), must have its elements scaled between 0 and 1. Mathematically we can describe the rescaling operation as:

$$\bar{\mathbf{I}} = \frac{\bar{\mathbf{a}}_i - \min}{\max - \min} \tag{4.4.1}$$

Where $\bar{\mathbf{a}}_i$ represents an individual element of the intensity vector, and max and min denote the maximal and minimal data values. The rescaling operation can be accomplished with either global or local maxima and minima. In this study, to account for all possible occurrences, the minimum digital count value will be set to 0 and the maximum value to 255. Note that the rescaling operation preserves amplitude information and provides a very useful mathematical view of the world. Consider the following pixel intensity vector and its normalized variation, $\bar{\mathbf{I}}_{norm}$.

$$\bar{\mathbf{I}} = \begin{bmatrix} 80 \\ 20 \\ 144 \\ 36 \\ 71 \\ 54 \end{bmatrix}$$

$$\bar{\mathbf{I}}_{norm} = \begin{bmatrix} 0.314 \\ 0.078 \\ 0.565 \\ 0.141 \\ 0.278 \\ 0.212 \end{bmatrix}$$

The *complement* of the input vector must also be calculated. This can be mathematically defined as:

$$a_i^c = 1 - a_i (4.4.2)$$

and we redefine
$$\bar{\mathbf{I}} \equiv (a, a^c)$$
 (4.4.3)

Accomplishing the complementation operation on the input pixel results in:

$$\bar{\mathbf{I}} = \begin{bmatrix} 0.314 & 0.686 \\ 0.078 & 0.922 \\ 0.565 & 0.435 \\ 0.141 & 0.859 \\ 0.278 & 0.722 \\ 0.212 & 0.788 \end{bmatrix}$$

The data at the input field of ARTa, F1a, is now a normalized and complemented vector

with 2N elements, where N is the number of bands. A value representing the target class with 2M elements, where M is the number of target classes, is similarly represented as a vector in input field F_1^b . The target class data label for this field must be encoded in a binary manner. If the previously defined training class examples are used, we will encode grass as 0001, water as 0010, pine trees as 0100, and deciduous trees as 1000. Their complements obviously are 1110, 1101, 1011 and 0111, respectively. As previously mentioned, the fuzzy ARTMAP reduces to a crisp set theory implementation in the presence of binary data. It is interesting to note that in this study that the ARTa module will be utilizing fuzzy logic, while its linked sister module will perform similar calculations using traditional crisp set theory mathematics.

The adjustment of the weights that provide the system's *long-term memory* will now be discussed. As in a regular ART network, all nodes in the input field are fully interconnected, and the F_1 activity vector will be represented by: $\bar{\mathbf{x}} = (x_1, ... x_{2N})$. Similarly, the *classification vector*, or field activity vector F_2 , will be represented by: $\bar{\mathbf{y}} = (y_1 y_{2L})$. Note that the number of nodes in either field can be arbitrary, but there must be more nodes in the classification field than classification categories. We will also define the weight vector (or long term memory trace) between the "jth" node of F_2 and all nodes in the input field as: $\bar{\mathbf{w}}_j = (w_{j1}, w_{j2N})$. Note that, while the crisp-set theory

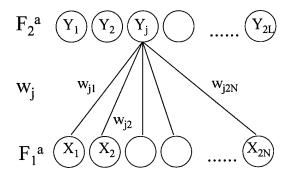


Figure 4.4.2 - depiction of the weight vector $\bar{\mathbf{w}}_j$ between the input field (F_1^a) and classification field (F_2^a)

implementation of the ARTMAP algorithm has both a bottom-up and a top-down weight vector, the fuzzy ARTMAP has only this single weight vector for each node. Initially this weight vector has all elements set to unity. Figure 4.4.2 illustrates the dynamics between the F_1 and F_2 fields.

As in a regular adaptive resonance theory network, the role of the classification field is to determine a "winning" node and pass this information to the rest of the system. In the fuzzy ARTMAP, this category choice is accomplished through the use of fuzzy mathematics. Consider the following *category choice* function:

$$T_{j}(\mathbf{\bar{I}}) = \frac{|\bar{\mathbf{I}} \wedge \bar{\mathbf{w}}_{j}|}{\alpha + |\bar{\mathbf{w}}_{i}|} \tag{4.4.4}$$

where "|.|" denotes the norm operator, which is defined as:

$$|\bar{\mathbf{a}}| = \sum_{i=1}^{N} \bar{\mathbf{a}}_i \tag{4.4.5}$$

The α term is a *choice* parameter which is set to be greater than zero. The fuzzy AND operator " \wedge " is a relative of the logical AND operator and simply returns a vector whose elements are the minimum value of the corresponding elements in the set of vectors being processed. This "min" operation is easily defined as:

$$(\bar{\mathbf{p}} \wedge \bar{\mathbf{q}})_i = \min(\mathbf{p}_i, \mathbf{q}_i) \tag{4.4.6}$$

Mathematically speaking, equation 4.4.4 determines the degree to which the weight vector is a *fuzzy subset* of the input vector. Note that when the weight and input vectors are very similar, $(\bar{\mathbf{I}} \wedge \bar{\mathbf{w}}_j) \cong \bar{\mathbf{w}}_j$ and T_j will approach unity, implying that node J is the best choice. A category choice is made when only one F_2 node becomes *activated*. A node is said to have become activated when it has a value of one and all others have a value of zero. This operation is often referred to as "winner take all". The chosen node index J is governed by the following simple relation:

$$J = \max\{T_i(\bar{\mathbf{I}}) : j = 1, 2...2L\}$$
(4.4.7)

In the event of a tie, the node with the lowest numerical value is chosen. When the signal from the input and classification fields reinforce one another, resonance occurs. This process occurs when:

$$\frac{\left|\bar{\mathbf{I}}\wedge\bar{\mathbf{w}}_{j}\right|}{\left|\bar{\mathbf{I}}\right|}\geq\rho\tag{4.4.8}$$

where ρ is the *vigilance parameter*. As ρ is increased, the algorithm has to be more and more certain of the of assignment of a particular exemplar to a specific class before classification is executed. This is exactly as mathematically stated in equation 4.4.8. Technically, the equation returns a measure of the degree to which the input vector is a fuzzy subset of the weight vector. More intuitively put, note that the proportion only becomes large (near unity) when the input and weight vectors have similar values. This is exactly why the weight vector is also termed a "long-term memory trace". The weight vector of each node essentially "learns" (defines) a multidimensional region that is populated solely by vectors from one target class. After the network is trained, new input vectors located within the bounds of this region are assigned to that class. Whenever an input pixel is determined to reside within the bounds of or close to a target region as determined by the vigilance parameter, resonance will occur between the input and classification fields and the same F_2 node will be activated. Learning will occur at this point, and this process is governed by the relation:

$$\bar{\mathbf{w}}_{i}^{new} = \beta(\bar{\mathbf{I}} \wedge \bar{\mathbf{w}}_{i}^{old}) + (1 - \beta)\bar{\mathbf{w}}_{i}^{old}$$
(4.4.9)

Note that when the weight vector is essentially a fuzzy subset of the input vector, then $\bar{\mathbf{I}} \wedge \bar{\mathbf{w}}_j \cong \bar{\mathbf{w}}_j$ and little "learning" will occur. This is desirable and leads to enhanced stability. The parameter β is termed a *learning-rate parameter* and is bounded between zero and one. For fast learning, $\beta \approx 1$. This makes the weights closely track the input vectors, and is useful when initially training the network. For fast encoding of noisy data sets (the typical real-world situation) the learning parameter is set to 1 until a node becomes initially activated. When a node is initially assigned to represent a target

classification class, it is said to have been *committed*. Once a node has been committed, the value of β is reduced. Though not inherently obvious at this point, it is important to note that the elements of the weight vectors can only decrease monotonically. This is directly related to classification boundaries expanding in feature space. This important facet of the algorithm will be highlighted in a simple two-dimensional and two-class example to follow.

If a pixel is determined not to fall within or close to a particular classification region, resonance will not occur. The degree of "closeness" to the classification region is user definable through the vigilance parameter. Resonance does not occur when the vigilance criterion (equation 4.4.8) is not met. This occurs when:

$$\frac{\left|\bar{\mathbf{I}} \wedge \bar{\mathbf{w}}_{j}\right|}{\left|\bar{\mathbf{I}}\right|} < \rho \tag{4.4.10}$$

When this happens, *mismatch reset* is said to have occurred, and a search operation begins. The algorithm determines if the pixel is close to or within any of the regions defined by the weight vectors of the F_2 nodes. If no suitable region can be found, another F_2 node can be committed or a new node can be created. When a new node is created, another classification region is defined internally. Once resonance is attained, learning can be accomplished by altering the node's weight vector as with the learning rule as previously described.

For insight into how this algorithm divides up feature space, consider the following two-dimensional example. Given a general feature vector, the preprocessing, or fields F_0 , will produce the normalized four-dimensional vector:

$$\overline{\mathbf{I}} = (\overline{\mathbf{a}}, \overline{\mathbf{a}}^c) = (a_1, a_2, 1 - a_1, 1 - a_2) \tag{4.4.11}$$

As expected, the weight vector will attempt to map these input values to a region of feature space through application of the learning rule. The weight vector, in complement coded form, can then be expressed as:

$$\bar{\mathbf{w}}_j = (u_j, v_i^c) \tag{4.4.12}$$

Geometrically speaking, the weight vector can be thought of as describing a rectangle in feature space. Consider the diagram in Figure 4.4.3. We will assign the name R_j to the region near the center of feature space. A measure of its size can be computed by adding its height and width as follows:

$$|R_i| = |v_i - u_i| \tag{4.4.13}$$

During learning, the region R_j grows as the elements of its associated weight vector decrease monotonically. Consider the case where a new pixel (denoted as $\bar{\bf a}$) meets category choice criteria for this same region. This will cause the very same classification field node to become active, and the elements of the weight vector will begin to monotonically decrease during learning. The algorithm seeks to determine the minimum-sized rectangle in feature space that will encompass all of the input vectors that cause this node to become active. At this point, we will introduce the fuzzy OR operator (denoted by the " \vee "). As might be expected, it is a relative of the crisp OR operator. Unlike the fuzzy AND operator, this process returns the maximum value of corresponding elements of the vectors. In feature space, the previously defined rectangle has enlarged (Figure 4.4.4) to reflect the decrease in the weight vector's elements and the assignment of the new data point to this class. The weight vector associated with this new region is then:



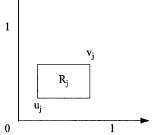


Figure 4.4.3 - weight vector represented as rectangle R_j in feature spac

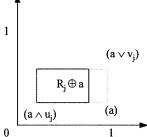


Figure 4.4.4 - region R_j has "grown" to include vector $\bar{\mathbf{a}}$

It is important to note that the weight vector essentially has "learned" the lower left and upper right corners of the new region. As already defined, the size of this new region is:

$$|R_i \oplus \overline{\mathbf{a}}| = |(\overline{\mathbf{a}} \vee v_i) - (\overline{\mathbf{a}} \wedge u_i)| \tag{4.4.15}$$

and the \oplus operator implies a bounded sum which cannot exceed some value. This process must be bounded by the vigilance parameter to prevent the entire feature space from being enclosed by a single rectangle:

$$|R_i| \le (1 - \rho)N \tag{4.4.16}$$

where N is the number of bands or dimensions being used (2 in this case). Note that as the vigilance parameter ρ is increased, the feature space is segmented by smaller and smaller rectangles and thus becomes more and more finely granularized.

In general, for an M-dimensional vector and given $\bar{\mathbf{A}}$, the set of all vectors that activate the node of interest, the following fuzzy-set statements can be made concerning the class' hyper-rectangle in feature space. The vertices of the hyper-rectangle are represented by the minimum and maximum values of the individual elements that encompass the vectors that define class $\bar{\mathbf{A}}$. Mathematically, this is simply:

$$u_j = (\wedge_j \bar{\mathbf{A}})_i = \min{\{\bar{\mathbf{A}}_i\}} \text{ and similalry, } v_j = (\vee_j \bar{\mathbf{A}})_i = \max{\{\bar{\mathbf{A}}_i\}}$$
 (4.4.17)

Recall that in the preceding two-dimensional case, u_j and v_j were the lower left and upper right corners respectively. It follows that the size as defined in equation 4.4.13 of the corresponding hyper-rectangle is:

$$|R_j| = |\vee_j \bar{\mathbf{A}} - \wedge_j \bar{\mathbf{A}}| \tag{4.4.18}$$

The corresponding weight vector can therefore be expressed as:

$$\bar{\mathbf{w}}_j = (\wedge_j \bar{\mathbf{A}}, (\vee_j \bar{\mathbf{A}})^c) \tag{4.4.19}$$

Applying the norm operator to this results in:

$$|\bar{\mathbf{w}}_i| = \sum_i (\wedge_i \bar{\mathbf{A}}) + \sum_i (1 - (\wedge_i \bar{\mathbf{A}})) = M - |\vee_i \bar{\mathbf{a}} - \wedge_i \bar{\mathbf{a}}|$$

$$(4.4.20)$$

Substituting into the size equation (4.4.13) for the hyper-rectangle yields:

$$|R_i| = M - |\bar{\mathbf{w}}_i| \tag{4.4.21}$$

Realizing that $|\bar{\mathbf{w}}_j| \ge \rho N$, we obtain the very useful realization:

 $|R_i| \le (1 - \rho)N \tag{4.4.22}$

which was utilized in the preceding example (eq. 4.4.16) without the benefit of this proof. It is worth mentioning again that this important result states that increasing the vigilance parameter ρ results in a decrease in the size of the corresponding target classification hyper-rectangles decrease in size. This produces a finely partitioned feature space with many classification hyper-rectangles. In feature space, this entire process basically learns an exciting variation of the classical stacked parallelepiped classification algorithm (Richards, 1993). The most important difference between the two implementations is that the fuzzy ARTMAP implementation permits what is known as *exception handling*, where separately recognizable subclasses are defined within larger classes. This aspect of the algorithm is depicted in Figure 4.4.5.

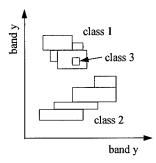


Figure 4.4.5 - stacked classification rectangles with exception handling in feature space

Illustration of a two-dimensional two-class example would demonstrate the utility of the previously defined category choice, vigilance criteria, and learning/weight adjustment rules. The two classes in this example will be water and pine trees and only the "blue" and "green" bands will be used. Consider pixels with the following values:

class	blue digital counts	green digital counts
water	230	26
pine	61	191
pine	71	204

After normalization and complement coding, the pixels are represented by the following vectors:

class	vector	t e	normalized green		_
		digital counts	digital counts	normalized blue	normalized green
water	I_1	0.9	0.1	0.1	0.9
pine	I ₂	0.24	0.75	0.76	0.25
pine	I_3	0.3	0.8	0.7	0.2

We will assume that the network is being initially trained. Category choice, or which classification node will become activated, is given by:

$$T_{j}(\overline{\mathbf{I}}) = \frac{|\overline{\mathbf{I}} \wedge \overline{\mathbf{w}}_{j}|}{\alpha + |\overline{\mathbf{w}}_{j}|} \tag{4.4.23}$$

Recall that all of the initial elements of the weight vector have a value of unity, and that the choice parameter α , is some small positive number. This results in:

$$T_{j}(\overline{\mathbf{I}}_{1}) = \frac{|\overline{\mathbf{I}}_{1} \wedge \overline{\mathbf{w}}_{j}|}{\alpha + |\overline{\mathbf{w}}_{j}|} \cong 1 \text{ for } j=1 \text{ to } 2L$$

$$(4.4.24)$$

which means that node one of the classification field will become active as the lowest numerical value of j is always chosen. Resonance occurs when the input and classification fields reinforce one another. This occurs when:

$$\frac{\left|\bar{\mathbf{I}} \wedge \bar{\mathbf{w}}_1\right|}{\left|\bar{\mathbf{I}}\right|} \ge \rho \tag{4.4.25}$$

We will choose to set the vigilance parameter $\rho = 0.9$. Since the node was previously uncommitted, resonance will occur because:

$$\frac{\left|\bar{\mathbf{I}} \wedge \bar{\mathbf{w}}_{1}\right|}{\left|\bar{\mathbf{I}}\right|} = 1 \ge \rho \tag{4.4.26}$$

Learning will now ensue. As previously stated, it is governed by the learning rule (equation 4.4.9). Given that we are in fast learning mode ($\beta = 1$) this results in the following calculation and weight vector:

$$\bar{\mathbf{w}}_{1}^{new} = \beta (\bar{\mathbf{I}}_{1} \wedge \bar{\mathbf{w}}_{1}^{old}) + (1 - \beta) \bar{\mathbf{w}}_{1}^{old} = [0.9, 0.1, 0.1, 0.9]$$
(4.4.27)

Note that this is exactly the input vector! If we perform similar calculations for the first pine tree pixel, we will find that resonance will not occur on the first node due to the value of the vigilance parameter. Due to this and the previously stated conditions, the second classification node will become active and its weight vector will be set equal to:

$$\bar{\mathbf{w}}_{2}^{new} = \beta(\bar{\mathbf{I}}_{2} \wedge \bar{\mathbf{w}}_{2}^{old}) + (1 - \beta)\bar{\mathbf{w}}_{2}^{old} = [0.24, 0.75, 0.76, 0.25]$$
(4.4.28)

Once again, the weight vector becomes the input vector. Recall that in feature space these weight vectors each define a two-dimensional rectangle. The maximum and minimum (lower left and upper right) coordinate pairs of the vertices of these rectangles can be calculated by simply taking the first two components of the weight vector and complement coding the last two elements. This results in two points in the two-dimensional feature space:

$$(u_1, v_1^c) = [0.9, 0.1, 0.9, 0.1]$$

and similarly, $(u_2, v_2^c) = [0.24, 0.75, 0.24, 0.75]$ (4.4.29)

Recall that the weight vectors can only decrease monotonically, and as they decrease the corresponding classification rectangle in feature space grows. When the next tree pixel is evaluated by the network, resonance does not occur with the first classification node due to the vigilance parameter, however resonance does occur with the second node as $\rho = 0.945 > 0.9$. As discussed earlier, learning will now occur resulting in the following new weight vector:

$$\bar{\mathbf{w}}_{2}^{new} = \beta(\bar{\mathbf{I}}_{3} \wedge \bar{\mathbf{w}}_{2}^{old}) + (1 - \beta)\bar{\mathbf{w}}_{2}^{old} = [0.24, 0.75, 0.70, 0.20]$$
(4.4.30)

and this weight vector defines a classification rectangle with the following coordinates:

$$(u_2, v_2^c) = [0.24, 0.75, 0.3, 0.8]$$
 (4.4.31)

But before the previous assertion can be made, we must check that the rectangle does not exceed the maximum allowed size given by:

$$|R_2| \le (1 - \rho)M = [0.3 - 0.24 + 0.8 - 0.75] < (1 - 0.9) * 2$$
 (4.4.32)

and we find that 0.11 < 0.2, so the rectangle grows within allowable size limits. Note that in feature space (Figure 4.4.6) the region describing the pine class has grown the minimum amount necessary to surround both pixels that belong to this class.

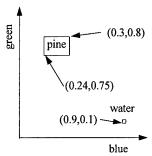


Figure 4.4.6 - two-dimensional feature space representation of the pine and water weight vectors

The inter-ART field, represented as map field F^{ab} in Figure 4.4.7, has two missions. First, it maps the classification from ART_a to the classification output of ART_b , and secondly it realizes the match tracking rule. The dynamics of the map field are illustrated in Figure 4.4.7 below.

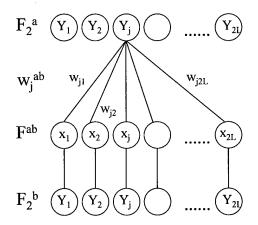


Figure 4.4.7 - Representation of the dynamics of the inter-ART field

We are initially interested in what occurs when the ART_a and ART_b modules are active and in agreement. When this occurs x^{ab} (the output vector from field F^{ab}) becomes:

$$\bar{\mathbf{x}}^{ab} = \bar{\mathbf{y}}^b \wedge \bar{\mathbf{w}}_{\mathbf{I}}^{ab} \tag{4.4.33}$$

which should be interpreted as the fuzzy AND of the classification output from the ART_b module and the weights between ART_a 's Jth classification field node and the map field. Note that all components of this weight vector, like the others previously discussed, are initially set equal to one (the one-to-one mapping between F^{ab} and F_2^{b} is always accomplished with unity gain). Fuzzy ANDing the classification field weight vector with the classification result from ART_b permits the network to derive a mapping from the input vectors that activate the same node in ART_a to the correct classification node in ART_b . Once node J in F_2^{a} learns to predict node K in F^{ab} , one element of the weight vector between them is set to one for all time. In our notation, this rule can be represented as:

$$w_{IK}^{ab} = 1 (4.4.34)$$

It is crucial to note that the activation of different nodes in F₂^a may be mapped to the same output classification class. This permits the mapping of "many to one". Understanding this result is vital to understanding one of the greatest strengths of this network. Even though many different grass pixels may activate different classification nodes in ART_a (and therefore must be located in different hyper-rectangles in feature space) they are nevertheless still part of the same classification class and will be correctly mapped to it. The "many-to-one mapping" is depicted in Figure 4.4.8 on the following page.

When there is a mismatch during training between the output of ART_a and the correct classification of ART_b, *match tracking* occurs. This is mathematically triggered when:

$$|\bar{\mathbf{x}}^{ab}| < \rho_{ab}|\bar{\mathbf{y}}^{b}| \tag{4.4.35}$$

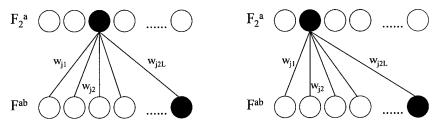


Figure 4.4.8 - Graphical representation of the mapping of many classification nodes to the same output classification class

The match tracking rule then increases ART_a's vigilance parameter ρ_a until the correct node in ART_a is activated, and this occurs when:

$$|\bar{\mathbf{x}}^a| = |\bar{\mathbf{I}} \wedge w_J^a| \ge \rho_a |\bar{\mathbf{I}}| \tag{4.4.36}$$

and this will drive the output of the field map to be:

$$\left|\bar{\mathbf{x}}^{ab}\right| = \left|\bar{\mathbf{y}}^b \wedge w_J^{ab}\right| \ge \rho_{ab} \left|\bar{\mathbf{y}}^b\right| \tag{4.4.37}$$

In the event that no node can be found that satisfies these equations, all of the nodes in F_2 are set to zero. In essence, by shutting down all classification nodes due to a pixel that does not map to any of the hyper-rectangles in feature space, the neural network is responding, "I don't know". This powerful result will cause pixels that are not in any of the classes to be mapped to the background class.

Once the network is suitably trained, the ART_b module is disconnected. Pixels from the image are sequentially presented to the preprocessing fields of ART_a and their resulting classification is read at the output of the map field. At classification time, the output of the map field is:

$$\bar{\mathbf{x}}^{ab} = w_I^{ab} \tag{4.4.38}$$

which is simply the weight vector between F_2^a and F^{ab} . Recall that this vector will have all of its elements equal to zero except for one whose value will be one. This vector simply contains the encoded classification class. When all of the nodes in F_2^a are equal to zero, the output from the map field is:

 $\bar{\mathbf{x}}^{ab} = 0 \tag{4.4.39}$

which implies a result of "I don't know" or assignment to the background class.

The fuzzy ARTMAP architecture is uniquely suited to classifying remotely sensed images. No other neural networks combine the great strengths of ARTMAP, such as ART dynamics, exception handling capability, and the ability to effectively deal with analog data in such a stable and rapid learning environment.

4.5 Reporting the Results

As previously discussed, the simple LANDSAT TM image in Figure 4.5.1 is composed of four major classes, water, grass, deciduous trees, and pine trees. Assume that the image is 100 pixels by 100 pixels. We will also assume that 15% of the image (1,500 pixels) is composed of deciduous trees, 25% is made up of pine trees (2,500), 20% is water (2,000), and the remaining 40% (4,000) is made up of grass.

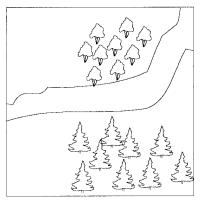


Figure 4.5.1 - depiction of LANDSATTM scene

The accuracy of a particular classification algorithm often is illustrated through the use of a simple mathematical construct termed a *confusion* or *error* matrix. Consider the confusion matrix in Figure 4.5.2, which represents the results attained by segmenting the artificial LANDSAT TM scene with a particular classification algorithm.

	grass	water	pine	leaf	classification total
grass	3,885	0	20	5	3,910
water	0	2,000	0	0	2,000
pine	90	0	1,985	392	3,178
leaf	25	0	495	1,103	912
ground truth total	4,000	2,000	2,500	1,500	10,000

Figure 4.5.2 - a simple confusion matrix

The entries along the bottom of the matrix represent the ground truth classes and the entries along the right edge represent the classification as performed by the algorithm. The classification total represents the sum across a particular row, while the ground truth total is calculated by summing down each column. The results in this matrix can lead to some important conclusions. The "grass" column indicates that of the 4,000 ground truth grass pixels, 3,885 were correctly classified, 90 were incorrectly classified as pine trees, and 25 were also incorrectly classified as deciduous (leaf) trees. Note that none of the grass pixels were incorrectly classified as water. This should not be surprising as their respective mean vectors are probably widely separated, leading to low classification error and little confusion. This is not true for the pine and leaf columns, where considerable confusion (between 20 and 26 percent) is evident between the two tree types. This confusion is not unexpected as the two mean vectors are likely to be separated only slightly, leading to some misclassification.

The overall accuracy of a classification algorithm often is reported as a *simple accuracy*. This metric is calculated by summing the correctly classified pixels along the diagonal of the confusion matrix and dividing by the total number of pixels. For the preceding confusion matrix, this results in a simple accuracy measurement of:

$$\frac{3885 + 2000 + 1985 + 1103}{10000} = 89.7\% \tag{4.5.1}$$

Note that this measure does not account for any off-diagonal terms in the confusion matrix. Also note that this figure of merit is artificially inflated due to the highly accurate, although easily accomplished, segmentation of the water pixels.

In an attempt to account for varying class content in an image, the *weighted* accuracy measurement has been proposed. It is calculated by first dividing the number of correctly classified pixels by the number pixels present in the class. This term is then divided by the number of classes present in the image. In the preceding case, this classification accuracy would be calculated and reported as:

$$\frac{\frac{3885}{4000} + \frac{2000}{2000} + \frac{1985}{2500} + \frac{1103}{1500}}{4} = 87.5\%$$
 (4.5.2)

Also note that this figure does not account for the off-diagonal terms in the confusion matrix.

To combat the problems associated with the simplistic computation of classification accuracy just described, a measure will be introduced that accounts for the off-diagonal terms, but compensates for chance agreement. This measurement is termed the *kappa coefficient* and is denoted $\hat{\kappa}$. The development that follows essentially summarizes the development in Rosenfield and Fitzpatrick-Lins (1986) with the considerations for other coefficients coming from Foody (1992).

The confusion matrix in Figure 4.5.3 is identical to that in Figure 4.5.2 with the addition of the simple row and column marginals:

	grass	water	pine	leaf	classification total	row marginal P _r (i)
grass	3,885	0	20	5	3,910	0.39
water	0	2,000	0	0	2,000	0.2
pine	90	0	1,985	392	2,467	0.25
leaf	25	0	495	1,103	1,623	0.16
ground truth total	4,000	2,000	2,500	1,500	10,000	
column marginal P _c (i)	0.4	0.2	0.25	0.15		

Figure 4.5.3 - a simple confusion matrix with row and column marginals added

The marginals, P_r and P_c , are simply calculated by dividing the sum across a row or down a column by the total number of data elements. With these simple calculations, the kappa coefficient can be calculated as follows:

$$\hat{\mathbf{K}} = \frac{P_o - P_E}{1 - P_E} \tag{4.5.3}$$

where the observed proportion of agreement P_o is defined as the proportion of the correctly classified pixels. Completing these calculations for the previously defined example results in:

$$P_O = \frac{3885 + 2000 + 1985 + 1103}{10000} = .8973 \tag{4.5.4}$$

This is simply the sum of the diagonal terms of the confusion matrix divided by the total number of data elements. The proportion of agreement due to chance, P_E , is defined as:

$$P_E = \sum_{i=1}^{M} P_r(i) P_c(i)$$
 (4.5.5)

where M is the total number of target classification classes (4 in this case). In this case:

$$P_E = \sum_{i=1}^{M} P_r(i) P_c(i) = 0.39 * 0.4 + 0.2 * 0.2 + 0.25 * 0.25 + 0.16 * 0.15$$

= 0.2825 (4.5.6)

Substitution yields a value for the kappa coefficient:

$$\hat{\kappa} = \frac{P_o - P_E}{1 - P_E} = \frac{.8973 - 0.2825}{1 - 0.2825} = 0.8569 \tag{4.5.7}$$

This value typically is multiplied by 100 and presented as a percentage. This results in a kappa coefficient of 85.69%, somewhat lower than the 87.5% weighted classification accuracy as previously calculated for the same confusion matrix.

Foody (1992) notes that P_E is calculated from the diagonal terms of the confusion matrix. These terms denote actual agreement, and therefore improperly inflate the proportion of agreement due to chance. He suggests utilizing the following measurement; named Brennan and Prediger's Kappa after its creators:

$$k_{B\&P} = \frac{P_O - \frac{1}{M}}{1 - \frac{1}{M}} \tag{4.5.8}$$

where M once again represents the total number of target classification classes. The 1/M terms can be justified by the argument that the marginal terms in a typical image classification algorithm are free parameters and not fixed *a priori*. Therefore the

probability of chance agreement reduces simply to 1/M. In this example, the metric has a value of:

$$k_{B\&P} = \frac{P_O - \frac{1}{M}}{1 - \frac{1}{M}} = \frac{.8973 - \frac{1}{4}}{1 - \frac{1}{4}} = .8631$$
 (4.5.9)

which is slightly larger than the kappa coefficient. Intuitively, the larger value makes sense, as we have removed some of the actual agreement which previously contributed to the probability of agreement due only to chance. This study will calculate both the classical and Brennan and Prediger's kappa coefficient for each image and each classification methodology and compare their results in actual use.

Classification accuracy obviously is one of the chief concerns in this study, but other metrics were applied to the various segmentation algorithms. They also were compared in terms of execution time required for image segmentation. The time function of the computer was queried prior to entering and after completing the segmentation phase of each algorithm. The difference between these two values is published with the results of each classification run. Note that the training time for the neural network will be included in this measure, while the creation of bounding polygons for the nPDF space will not. The creation time of the nPDF classification polygons requires direct user intervention and considerable care to produce accurate results. If possible, the various modules will also be "profiled" to determine where most of the computing time is spent. The end result of compiling and presenting these various measurements will produce a "snapshot" of the best conditions and related difficulties of the differing approaches.

5.0 Using the Classification Modules in the AVS Environment

The Advanced Visualization System from Advanced Visual Systems was chosen to support this study for a number of reasons. Most importantly, this system provides an extremely powerful and user extensible data visualization and image computing environment for the programmer. A competent "C" programmer can expect to be able to write AVS modules in no more than a couple of weeks. The very rapid ramp-up time can be attributed to relieving the programmer of the considerable intricacies of the X-Windows graphical environment and simplifying the problems of data transfer between the modules. As such, virtually all modules for the environment are composed of two distinct code sections. The first defines the interfaces with other modules and how control parameters are passed to the second code section. This second section, the compute function, is almost entirely composed of standard C calls, the only exceptions being the routines to access shared data between the modules. The complete source code for each module developed for this study is included in appendix A of this report.

Possibly the most attractive feature of the AVS environment is that computational chains can be readily represented as "networks" or "procedures" of simple modules. Imaging operations that traditionally would take considerable time to uniquely code by hand, either in a low-level programming language or a mathematics package, can be created by merely connecting a few modules into a network. In addition, many modules for common imaging operations, such as reading, writing, and displaying standard image formats, have already been developed and tested. This study extended the use of AVS at RIT into image classification, but it required only a handful of specialized modules. All of the inherently compatible base functionality already had been developed.

In the following sections of this report, a representative processing network for each of the classification operations will be described along with detailed operating instructions for each of the classification modules. As such, this chapter can serve as a user's guide to image processing with the supplied modules.

5.1 Collecting Training Data in the AVS Environment

Two separate modules and associated networks were constructed for this study to support the collection of training data for the classification algorithms. The method by which training data is interactively defined by the user by superimposing polygons on the image proved to be a difficult project for even an experienced software engineer at RIT. For this reason, its development was delayed and a method to test the evolving classification modules in a timely manner became critical. To this end, the *Fuzzy K-Means* module was developed and implemented. This module serves a dual role. Besides being able to collect spectrally pure training data, it can also be used for unsupervised image classification. Consider the AVS network in Figure 5.1.1.

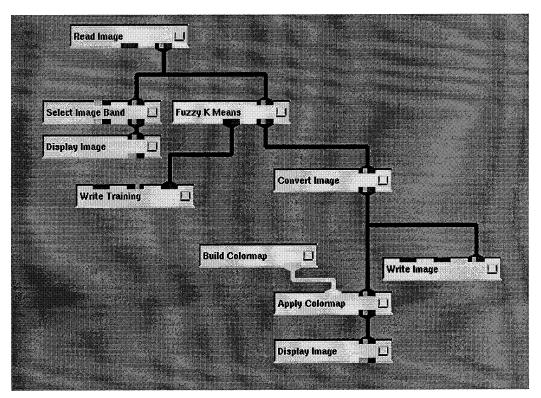


Figure 5.1.1 - Depiction of Fuzzy K-Means network

In operation, the network reads in a user-selected image, selects a single band, and displays the image. Pointers to the multispectral image data in shared memory are then passed to the to *Fuzzy K-Means* module. The control panel for the module is depicted in Figure 5.1.2. The user provides the algorithm with a number of parameters before

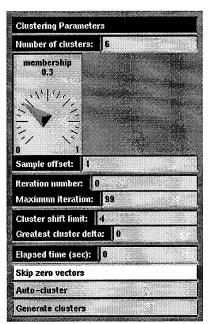


Figure 5.1.2 - Depiction of the control panel for the Fuzzy K-Means module

clustering can occur. First, the user must enter the number of clusters to locate and select a membership value. By setting the membership to a high value (near 1), a few pixels in very tight spectral groups will be collected for each cluster. When operated in this manner, the module supports the collection of training data. If the membership is instead set to a low value, the image can be classified in a unsupervised manner by calculating the cluster centers and performing a form of minimum-distance-to-the-means classification with respect to the value of the membership function. The "Sample offset" parameter permits the input image to be subsampled. By entering a value of two, every

other pixel in every other row of the image will be used for cluster computations. As expected, increasing this value dramatically reduces processing time as only a fraction of the pixels in the input image need be processed. The "Maximum iteration" parameter permits the user to define the maximum number of clustering iterations. Similarly, the "Cluster shift limit" parameter is used by the algorithm to determine when the clustering algorithm has converged. The value of four indicates that the greatest shift of any cluster from one iteration to the next must be less than or equal to four to end processing. Once the user has supplied these parameters, only the "Generate clusters" or "Auto-cluster"

toggle switch need be selected. The auto-clustering feature will eventually allow a number of images to be processed successively. The module then executes the compute function code. It first selects the appropriate number of pixels pseudorandomly from the input image to serve as initial approximations of the cluster centers. If the "Skip zero vectors" toggle has been set, the module checks for and skips any pixels with zero magnitude. This permits segmented images to be rapidly processed. It then allocates a "membership" array for each cluster that has the same dimensions as the input image. The membership value for each pixel from the image or subsampled image is then calculated with respect to each cluster center and then the center approximations are recomputed. This process is repeated until the algorithm converges and the display is updated to show the iteration number and greatest cluster shift. The clustering algorithm obviously is computationally intensive and may take a considerable amount of processing time before convergence occurs. Once the conditions for convergence are met, the elapsed time is reported and the required number of iterations is displayed. At this point, the training data set is collected and the unsupervised classification map is constructed. The membership values with respect to each cluster center for each pixel in the input or subsampled image are compared to find the maximum value. If this value is equal to or greater than the value membership function, the pixel is assigned to the corresponding cluster and its multispectral pixel is added to the training data linked list. If the greatest membership value is not greater than or equal to the value of the membership parameter, the pixel is assigned to the background class. The resulting training data in the form of a linked list is then transferred to the write training module so that it can be optionally saved to disk. Similarly, the classification map can be saved to disk in a standard image format. A colormap is constructed and applied to the unsupervised classification map so that the clustering and classification results can be readily visualized.

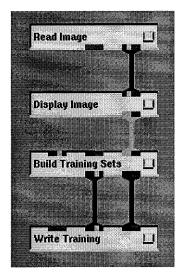


Figure 5.1.3 - Depiction of network to gather user defined training data

,
Training Set Count 1
Current Training Set 1
Create New Training Set
Delete Current Training Set
GIS Value 0
Size of Training Set 5811
Polygon Count 4
Current Polygon 4
Create New Polygon
Delete Current Polygon
Vertex Count 4
Current Vertex 1
X Location 514
V Location 206
Delete Vertex
Gather Training Data

Figure 5.1.4 - Depiction of the control panel for the Build Training sets module

The network that supports gathering training data from the input multispectral image in an interactive manner will now be discussed. This module, and the supporting modules that read and write the training data structures, were written by Stephen Schultz, resident software engineer at RIT. The programming of these modules required an in-depth understanding of the X windows environment that is currently beyond the capability of the author. Consider the network in Figure 5.1.3. This network reads and displays the user-selected image. References to the input data are passed to the Build Training Sets module. The control panel for this module is depicted in Figure 5.1.4. To define training-class polygons, the user simply designates the polygon vertices with the cursor and a mouse click. The module allows multiple polygons to define a single class. Additional polygons are added to the current training set by selecting the "Create New Polygon" button. After the user has defined a given class, the process is repeated for a new class after selecting the "Create New Training Set" button. To correct any errors, the module permits the user to remove the current vertex, polygon, or entire training class. A subsection of an image with

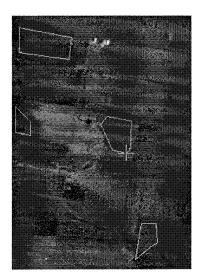


Figure 5.1.5 - Depiction of image with overlaid training class polygons

overlaid training class polygons is depicted in Figure 5.1.5. After all polygons for all classes have been defined, the user selects the "Gather Training Data" button. This causes the module to retrieve the designated multispectral pixels from the input image, label them as belonging to a given class, and chains them together in the form of a linked list. The linked list is then passed on to the *Write Training* module where it is written to a user-specified disk file. The training data file can then be readily processed by the modules that support the classification operations.

5.2 Gaussian Maximum Likelihood in the AVS Environment

Accomplishing image classification with the *GML Classify* and *Class Statistics* modules is a straight forward process in the AVS environment. Before an image can be classified, the representative statistics for the training classes must be calculated. Figure 5.2.1 depicts the AVS network that is used to create the required statistics files. Training data collected by either the fuzzy K-means or the user-interactive module is transferred in

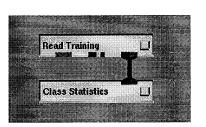


Figure 5.2.1 - Depiction of the class statistics network

Fraining class statistics	
Statistics file (".sta):	90 D
Dir:/swn8270/statistics_files	
File:/landcover_sub_5c7m.sta	
/ (swn8270) city_sub_5c7m.sta city_sub_5c9m.sta	
landcover_sub_5c7m.sta	E
New Dir New File	
/iew all file types	
Number of training pixels: 211902	
lumber of bands: 6	
Hapsed time (sec): 12	
Auto-generate statistics file	
Generate statistics file	
	400000

Figure 5.2.2 - The class statistics module control panel

the form of a linked list from the *Read Training* module to the *Class Statistics* module. The data is then moved from the linked list to an internal data structure to support further operations. The control panel that supports the user interface to the statistics module is depicted in Figure 5.2.2. Once the training data has been received and an output statistics filename has been selected, the interface is updated. It displays the number of training sets or classes, the total number of training class pixels, and the dimensionality of the training set. When the user selects either the "Generate statistics file" or "Auto-generate statistics file" button, the module begins the compute function's statistical operations. In more somewhat greater detail, the mean vector, the variance-covariance matrix, and its inverse are calculated for each training class. Matrix inversion is accomplished through Lower-Upper (LU) decomposition and backsubstitution. When these operations are complete, the interface is updated to

reflect the elapsed processing time and the resulting class statistics are written to the user specified disk file. A sample statistics file is depicted in Figure 5.2.3.

```
bands
   classes
These are the mean vectors:
101.558304 87.162682 79.549095 108.158653 117.790672 91.485168 3473.000000
105.620270 99.025017 91.263634 127.766518 130.973694 98.951248 1559.000000
These are the inverted matrices:
0.148350 -0.031817 0.079483 -0.010912 -0.002541 -0.030949
-0.031817 0.339271 -0.272071 -0.005770 0.050755 0.034068
0.079483 -0.272071 0.444432 0.002016 -0.055556 -0.025385
-0.010912 -0.005770 0.002016 0.160764 -0.005757 0.015016
-0.002541 0.050755 -0.055556 -0.005757 0.211132 -0.045791
-0.030949 0.034068 -0.025385 0.015016 -0.045791 0.203757
0.402535 -0.241097 0.073095 0.037794 0.001006 -0.067547
-0.241097 0.601827 -0.238123 -0.037646 0.051879 0.028189
0.073095 \  \, -0.238123 \  \, 0.422447 \  \, 0.031728 \  \, -0.047003 \  \, 0.000208
0.037794 -0.037647 0.031728 0.184273 -0.029169 0.011340
0.001006 0.051879 -0.047003 -0.029169 0.233353 -0.056189
-0.067547 0.028189 0.000208 0.011340 -0.056189 0.237680
These are the natural logs of the determinants:
9.728889 7.587222
These are the normalized vc matrices:
7.810011 -0.872250 -1.863393 0.423204 0.059587 1.082154
-0.872250 6.033162 3.718243 0.165424 -0.659772 -0.838456
-1.863393 3.718243 4.887069 -0.022048 0.320907 -0.222125
0.423204 0.165424 -0.022048 6.296008 0.039846 -0.421174
0.059587 \ -0.659772 \ 0.320907 \ 0.039846 \ 5.272109 \ 1.341222
1.082154 -0.838456 -0.222125 -0.421174 1.341222 5.517158
3.484727 1.426702 0.223407 -0.536731 -0.159543 0.808821
1.426702 2.768975 1.273246 -0.003784 -0.368406 -0.010975
0.223407 1.273246 3.100528 -0.270882 0.305396 -0.005112
-0.536731 -0.003784 -0.270882 5.693850 0.592060 -0.283535
-0.159543 -0.368406 0.305396 0.592060 4.767593 1.096926
0.808821 -0.010975 -0.005112 -0.283535 1.096926 4.711347
These are the determinants:
16795.867188 1972.824951
```

training class statistics file for AVS GML

Figure 5.2.3 - Sample statistics file

Once a statistics file has been created, image classification can be accomplished readily. Consider the network in Figure 5.2.4 on the following page that is utilized to perform GML classification.

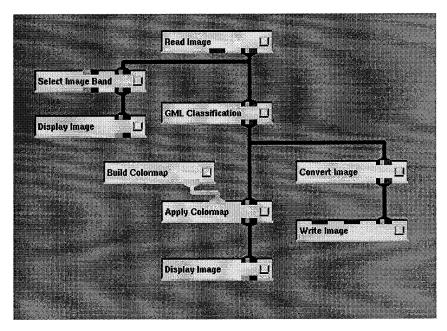


Figure 5.2.4 - GML classification network

The network reads the multispectral image and permits the user to select a single band to display the input image. A reference to the multispectral image data (in the form of a pointer to shared memory) is transferred to the *GML Classification* module. The control panel for module is depicted in Figure 5.2.5. This parametric classifier requires a model of the training data created by the *Class Statistics* module as previously discussed. Once the user selects a valid statistics file, the data from the selected file is printed to the standard output device and the interface is updated to reflect the classification parameters, the number of target classes, and the dimensionality of the data. At this point, the user need enter only an appropriate value for the Chi squared (χ^2) distance and select either the "Generate GML map" or "Auto-generate GML" button. The auto-generation feature allows the same image to be easily reclassified by just entering a different value of χ^2 . The module then enters its compute function. The "Skip zero vectors" toggle allows segmented images to be rapidly processed. Before being processed, the magnitude of

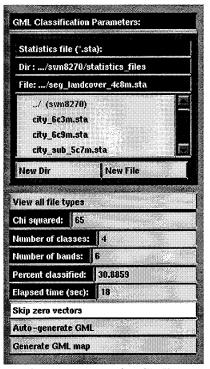


Figure 5.2.5 - The GML classification control panel

each pixel is calculated; if zero, the pixel is skipped. It is important to note that the Mahalanobis distance for each non-zero pixel in the input image is then calculated with respect to the mean vector of each target class utilizing its unique variance-covariance matrix. As expected, if the image size or the number of target classes is increased, classification time proportionally increases. If the minimum distance value to one class is less than that of the user input value for χ^2 , the pixel is assigned to that class. The value in the classification map at the position of the input pixel then is updated to reflect this assignment. If the minimum distance exceeds that of the limiting value, the pixel is assigned to the background class. Once the entire classification map is constructed in

the manner just described, the interface is updated to reflect the elapsed computation time in seconds. The network then constructs a colormap and applies it to the classification map so that the classification results can be readily visualized. The classification map is then converted to a standard image format and optionally is written to a user-defined file.

5.3 Performing nPDF Classification in the AVS Environment

The inherent graphical nature of the AVS environment is well suited to performing classification with the n-Dimensional Probability Density Function (nPDF) algorithm. Recall that this approach requires that the multispectral training data must first be projected into "nPDF" space to construct a LookUp Table (LUT) for image classification. The layout in Figure 5.3.1 depicts the AVS network that is used to project the multispectral training data into the two-dimensional nPDF space.

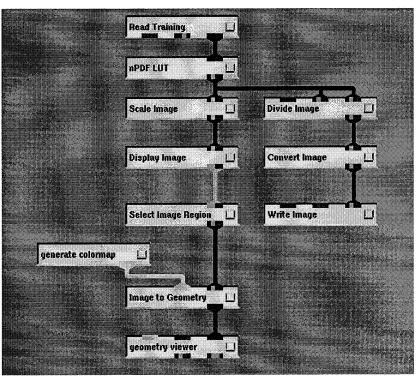


Figure 5.3.1 - Depiction of the network to project training data into nPDF space

This network reads in a user-specified training data file and passes it as a linked list to the $nPDF\ LUT$ module. At that module, the training data is transferred from the linked list into a more easily manipulated internal data structure. The control panel for the nPDF

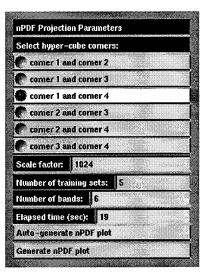
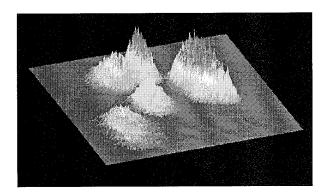


Figure 5.3.2 - Control panel for the nPDF LUT module

LUT module is depicted in Figure 5.3.2. The user then selects a pair of hypercube pairs by depressing one of the radio button options, and enters a value for the scale factor for the resulting nPDF projection. After these two parameters have been supplied, the user need only select the "Generate nPDF plot" or "Auto-generate nPDF plot" to begin the projection process. The auto-generation feature allow the same input training set to be repeatedly projected with a variety of corner choices and scale factor values. Once the module enters the compute function, the interface is updated to reflect the

dimensionality and the number of classes in the training data set. The algorithm then projects each pixel from the training set into nPDF space as defined by the corner choice and scale factor parameters. When all pixels have been processed, the interface is updated to display the elapsed processing time and the projection is passed to the rest of the network. First, the nPDF projection is divided by itself to form a binary image, converted to a standard image file format, and then optionally written to a disk file. The binary projection image must be processed by another network before it can be used as a LUT for classification purposes. The projected image is scaled and displayed to permit visual inspection. If no bundles of the training data overlap, good classification results can be expected. If the bundles do overlap, the corner pairs and scale factor are varied until the bundles no longer intersect, or such intersection is minimized. Continuing on with the network, a subsection of the displayed image can be selected. A colormap is then generated and applied to this subsection. The resulting nPDF projection can be converted to a height field. The resulting colored three-dimensional field can be viewed

with the AVS geometry viewer. In Figure 5.3.3, the nPDF projection for a five-class training set is depicted as a flat projection and as a height field.



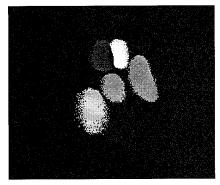


Figure 5.3.3- nPDF projection of training data depicted as a height field and a flat projection.

As mentioned in section 4.3 of this report, the nPDF projection must be processed before it can be used as a LUT for classification purposes. In a manner similar to that for constructing polygons around training data of interest, a boundary is drawn around each individual cluster. Care must be taken to completely encompass a class and to provide precise boundaries between clusters, as the accuracy of the resulting classification depends entirely on the accuracy of the LUT. It is also important to realize that the complete spectral extent of a class must be encircled by its class polygon in nPDF space. One method for accomplishing this is to attach a piece of acetate to the computer's display and sketch the position of the training data clusters. Once this has been accomplished, the nPDF projection of the entire image to be classified is then displayed. By utilizing a straightedge and a pen, the projection of the entire image can be segmented readily into classification regions. Once a classification region has been completely surrounded, the region is then filled with the numerical value for that class. Each individual region is saved to a disk file as an image. The network in Figure 5.3.4 page is utilized to create the individual classification regions and fill them with the

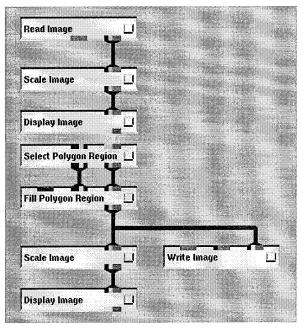


Figure 5.3.4- AVS network to create individual classification regions in nPDF space.

appropriate class value. The network reads in an image (typically the nPDF projection of the image to be classified) scales its values to promote interpretability, and displays it. The classification regions are individually designated with the Select Polygon Region module. These regions are passed onto the Fill Polygon Region module where the designated classification regions are filled with the appropriate class value. The separate classification region images are then written to a

disk file in a standard format.

Once the individual classification regions have been designated, they must be combined into a single LUT. The network depicted in Figure 5.3.5 is utilized for this purpose. This AVS procedure reads in two separate classification region images at a time, scales each image, and displays them. They are then combined with logical OR operation as provided by the *Or Image* module. The resulting image is written to a disk file. In operation, the user must read the class-one and class-two image and combine them to form the intermediate LUT for classes one and two. This process is repeated until all of the individual class images have been combined into a single LUT.

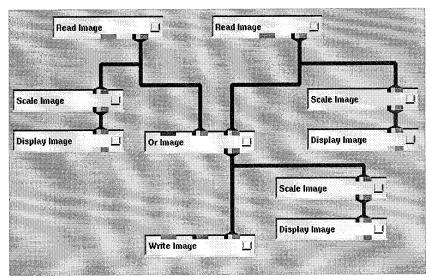


Figure 5.3.5- AVS network to combine the individual classification region images into a LUT.

The images in Figure 5.3.6 highlight the process from nPDF projection to classification LUT.

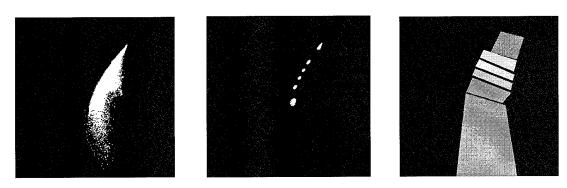


Figure 5.3.6- nPDF projection of an image, nPDF projection of training data from image, and resulting classification LUT

Once the LUT has been constructed, the image classified easily. The AVS algorithm for nPDF classification is depicted in Figure 5.3.7. This network reads in the LUT, displays it, and converts it to the format expected by the classifier. Similarly, the input image is read, a single band is selected, and the image is displayed. The LUT data

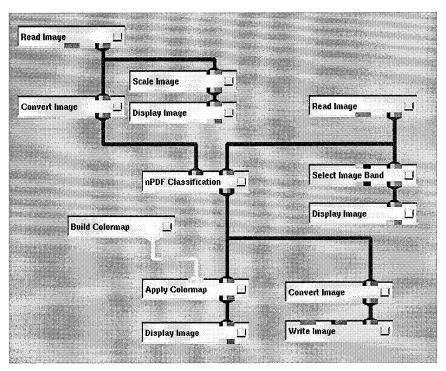


Figure 5.3.7- Depiction of network to accomplish nPDF classification

and the multispectral image data are passed to the *nPDF Classification* module. The control panel constituting the user interface to this module is depicted in Figure 5.3.8. To begin classification, the user needs to select the same corners of the hypercube as were used to project the data. At present, AVS does not permit this information to be transferred in any other manner. The simplest workaround is to include the corner choice in the name of the LUT. Once the user has supplied the corner-choice selection, the "Classify Image" or "Auto-classify Image" must be selected before classification can begin. The auto-classification feature eventually will allow multiple images to be successively processed by the module. Once classification has begun, the interface is updated to reflect the scale of the LUT, which is either its height or width dimension. The "Skip zero vectors" toggle allows for the rapid processing of images with many zero

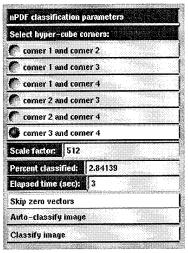


Figure 5.3.8 - Control panel for the nPDF Classification module

magnitude vectors. Each non-zero pixel from the input image is projected into nPDF space as defined by the combination of the corner choice and the scale factor. To achieve classification, the coordinates of each input pixel in nPDF space are used to reference a location in the LUT. If the pixel projects into one of the classification regions, the numerical value of that region is retrieved. If instead the pixel projects onto an undesignated region, the pixel is assigned to the background class. Note that increasing the number of classes has no impact on classification

time, but the LUT will be more difficult and time consuming to generate. Once all of the input image's pixels have been classified, the elapsed computational time is displayed. The network completes operation by building a colormap, applying it to the classification map, and displaying the results to aid visual inspection. The classification map is then converted to a format to support standard image formats and is may be written to a disk file.

Any classification algorithm can also be utilized for image *segmentation*. This operation screens out all pixels that do not belong to a desired class and forwards all multispectral pixels that do compromise a selected class. Instead of creating a classification map, a new multispectral image is created comprised solely of the desired class or classes.

Image segmentation via the nPDF algorithm will be used as the first step in *hybrid* image classification. In this case, the term hybrid implies that a nPDF segmented image will be passed to either the GML or fuzzy ARTMAP algorithm for further processing. In this manner, the strengths of either classification algorithm can be tested on tightly

grouped spectral classes. The network in Figure 5.3.9 supports the first phase in hybrid image classification by nPDF segmentation.

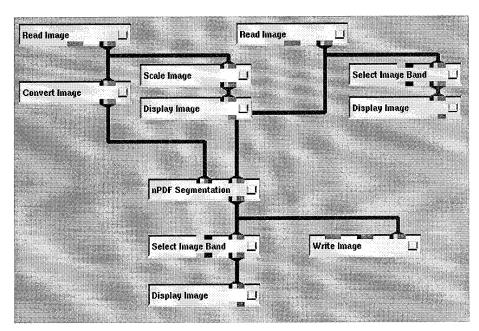


Figure 5.3.9 - AVS network to accomplish nPDF image segmentation

This AVS procedure functions identically to that for nPDF classification with the exception that it produces a multispectral image of the class or classes defined in the LUT. The resulting image is then written to disk in a standard format.

5.4 Accomplishing Fuzzy ARTMAP Classification in the AVS Environment

Accomplishing image classification with the *Make ARTMAP* and *Fuzzy ARTMAP* modules is a very similar to the process outlined for the GML module. Before an input image can be classified, a fuzzy ARTMAP neural network and associated parameter file must be created from the training data. The parameter file conveys information about the constructed network such as the dimensionality of the input space, the number of ART_a classification nodes, and the number of target classes (or ART_b classification nodes). A complete commented parameter file is depicted in Figure 5.4.1.

```
#define randomInit - seed for random number generator "1" = read time clock
          #define orderedSet "1" = read in the patterns in the same order as original file
          #define employ_weighting "1" = input features are differentially weighted
          #define on line - "1" = system goes through training set once
          #define num voters
          #define num_runs - number of complete training runs
10
          #define max iterations - maximum training iterations
          #define complement "1" = complement is presented
          #define a_length - the dimensionality of the input space
2
          #define b length - the dimensionality of the output space
2
          #define num_data_category - number of classes
          #define train pats - the number of training patterns
700
          #define predict_pats - the number of predict patterns
300
          #define test pats - the number of test patterns
          #define on_line_recast - method of recasting to handles inconsistent cases
          #define dnInit - the initial top down weights of both ART modules
1.0
          #define Alpha - parameter used in choiceOrderfunction of ART1
0.001
          #define epsilon IA-match -> rho goes to current match + epsilon.
0.001
           #define rate - under learning, wij -> (1 - rate) * wij + rate * fast learn_limit
1.0
           #define z_bar - in art1.c, if top down weight drops below zbar, both weights -> 0
0.0
          #define min_arho - minimum ART-A rho value
0.0
           #define brho - minimum ART-B rho value
1.0
          #define noise_rate at which recent success or failure change confidence of nodes
0.0
           #define noise tolerance below which an ART-A node will be destroyed
0.0
           #define trace - if > 0, then progresses of program will be reported
          #define trace_weight - allows features to be weighted separately
0
           #define display_confusion matrix - if 1, confusion matrix is displayed
           #define incorporate_rule
           #define extract rules
0
0
           #define quantize rules
           #define quantization_step
0
0
           #define individual match tracking
           #define num_F2_winners - number of winning classification nodes
0.0
           #define threshold
```

Figure 5.4.1 - Example ARTMAP parameter file

In general, a casual user need not be concerned with many individual parameters in the file as they are either defaults, have been optimized to process multispectral images, or are automatically updated by this module. The neural network file that is created by this module contains the weight vectors for each node in both ART modules, and the values stored in the inter-ART field which maps an ART_a classification node to an ART_b classification node representing the output class. The AVS procedure pictured in Figure 5.4.2 depicts the AVS network that is used to create the required neural network files.

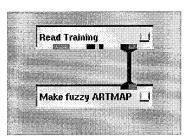


Figure 5.4.2 - Depiction of the network to construct the parameter and network files

As with the other classifiers, training data collected either by the fuzzy K-means or the user interactive module is transferred in the form of a linked list from the *Read Training* module to the *Make fuzzy ARTMAP* module. The data then is moved from the linked list to an internal data structure to support further processing. The control panel that supports the user interface to the *Make fuzzy ARTMAP* module is depicted in Figure 5.4.3.

Once the training data has been received and a filenames for both the parameter and network files have been selected, the interface is updated. It displays the number of training sets or classes, the total number of training class pixels, and the dimensionality of the training set. At this point, the user must select a value of the vigilance parameter (ρ) for the ART_a module. Recall that this determines the size of the region in feature space associated with a given node. Increasing ρ will decrease the maximum allowable size of the hyper-rectangle in feature space resulting in finely granulized classification and the creation of a large number of nodes. As expected, if the user selects a smaller value for the vigilance parameter, the classification regions in feature space grow and fewer nodes need to be created. The "Recast inconsistent cases" button permits the algorithm to check for inconsistencies in the training data. For example, if there were

some grass pixels in the tree class and a separate grass class, this preprocessing algorithm would attempt to relabel the incorrect pixels. At this point, the user need only select a

	ameters
Parameter file (*.pa	ur):
Dir :/swn8270/pa	rameter_files
File:/parameter_	files/landcover.par
/ (sym8270) city.par landcover.par new.par	
New Dir	New File
Network file (*.net)	
Dir:/ARTMAP_n	
File:/landcover.n	reministrativa (1900)
/ (swn8270) city.net landcover.net out.net	= = = = = = = = = = = = = = = = = = =
New Dir	New File
View all file types the for ARTa 0.96	
the for ARTb 1	
Number of training p	attems: 32421
Number of training cl	asses: 5
15 (1) G1 (1) X 245 (2) \$7.5 (4) 25 (4) \$1	6
Learning iteration:	1
Maximum iteration: Elapsed time (sec):	10 21
ARTa classification (nodes: 63
Update parameter fil	
Jpdate parameter fil Recast inconsistent :	cases

Figure 5.4.3 - Depiction of the control panel for the Make fuzzy ARTMAP module

value for ρ and either the "Generate network" or "Auto-generate network" button to create the fuzzy ARTMAP neural network. The auto-generation feature permits the network to be easily recreated for different values of the vigilance parameter. The module then enters its compute function. As each of the training class pixels is operated upon, the region into which it fits best with respect to the vigilance parameter must be determined. If found to fall within a region corresponding to a classification node, no further action need occur. If near to a classification region, and the degree of "nearness" is controlled by ρ , the weight vector of the node is updated and learning has occurred. If the pixel does not fall in or near any classification region, a new node is created. Once all training class pixels have been processed to 100% recognition, the interface is updated to reflect the number of classification nodes, the number of learning iterations, and the elapsed computation time. The network and parameter files are then written to disk.

At this point, image classification with the Fuzzy ARTMAP module can be readily accomplished. Consider the network depicted in Figure 5.4.4.

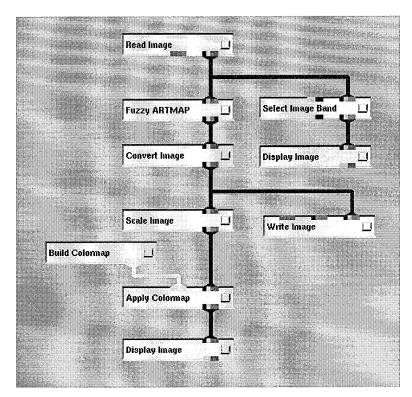


Figure 5.4.4 - Depiction of the network to perform fuzzy ARTMAP image classification in the AVS environment

The AVS procedure reads in a multispectral image and permits the user to select a single band to display the input image. A reference to the multispectral image data (in the form of a pointer to shared memory) is transferred to the *Fuzzy ARTMAP* module. The control panel supporting the user interface to this module is depicted in Figure 5.4.5. To perform image classification, this non-parametric classifier requires both the parameter and network file created by the *Make ARTMAP* module as previously discussed. Once the user selects a valid parameter and network file, the data from both the selected files is read from disk files and displayed on the standard output device. The module's interface

Parameter file (*.pa	W. A. C. WINGTON
Dir:/swn8278/pa	
File:/parameter_	
/ (swn8270)	
city.par	
city_6c9m88r.p:	v.
city_water.par	T. J. D.
New Dir	New File
Salate (1995)	
Network file (*.net)	
Dir:/ARTMAP_n	
	neural_nets/city.net
/ (swn8270)	
city.net	
city_6c9m88r.n	at .
city_water.net	Ē
New Dir	New File
a de la companya de	AND THE STREET
/iew all file types	
ho for ARTa: 0.88	
ARTa classification	nodes: 8
lumber of training c	lasses: 6
ercent classified:	96.7222
lapsed time (sec):	50
ikip zero vectors	
and the second second section of the second	sification map

Figure 5.4.5 - Depiction of the control panel for the fuzzy ARTMAP module

also is updated to reflect important classification parameters to include the value of the vigilance parameter, the number of target classes, and the number of classification nodes. At this point, the user need only select either the "Generate classification map" or "Auto-generate classification map" button to continue. The auto-generation feature allows the same image to be re-classified by just selecting different network and related parameter files. The module then enters its compute function. The "Skip zero vectors" toggle allows rapid processing of segmented images. It is important to realize that each non-zero pixel in the input image must be compared to each classification node's weight vector. If the pixel falls within the classification region of a node, it is assigned to that class. If it does not fall within any classification region, it is assigned to the background class. The value in the classification map at the same position as each input pixel is then updated to reflect this assignment. Once the entire classification map is constructed in the manner just

described, the interface is updated to reflect the elapsed computation time in seconds.

The network then constructs a colormap and applies it to the classification map so that the classification results can be readily visualized. The data comprising the classification map is then converted to support standard image formats and is optionally written to a

user defined file. As expected, if the image size or the value of the vigilance parameter is sufficiently large to force the creation of many classification nodes, classification time correspondingly increases.

5.5 Using the Confusion Matrix module in AVS

Once the images have been classified by the various algorithms, the classification accuracy needs to be assessed. This is a simple process in the AVS environment after a *truth* image has been constructed. A truth image is a classification map constructed by hand or by a trusted algorithm that reflects ground truth. Consider the AVS network in Figure 5.5.1.

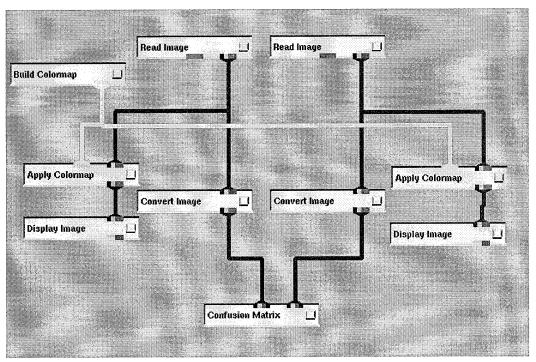


Figure 5.5.1 - Depiction of the network to assess classification accuracy

This network compares a classification map constructed by one of the classification modules and a corresponding truth image. A colormap is constructed and applied to both incoming images, and the resulting colored classification maps are displayed to aid visual inspection. The classification map and truth data are then converted to a format compatible with the *Confusion Matrix* module. This module checks to ensure that the two data sets are comparable. In specific, it checks that the image sizes are equal and that

the same number of classes are present in each image. Note that it is critical that the truth image be connected to the leftmost port and that the classification map being evaluated be connected to the rightmost port of the module. To aid in correct usage, the control panel for the *Confusion Matrix* module is labeled to minimize errors. The user interface for the

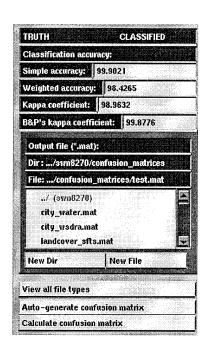


Figure 5.5.2 - Depiction of the control panel for the Confusion Matrix module

module is depicted in Figure 5.5.2. Once the module has received the reference to the input data and a filename for the confusion matrix, the user need only select the "Calculate confusion matrix" or "Auto-generate confusion matrix" to begin operation. The auto-generation feature permits differing classification maps from the various modules to be rapidly compared to a given truth image. When the module enters the compute function the confusion matrix is initially formed. Each pixel in both the classification map and truth image are compared in pairs. The value of the pixel in the truth image is used to index the column of the confusion matrix, while the value of the pixel in the classification map is used to index the row. If the values are the same, implying

agreement between classification and truth, an on-diagonal term is incremented. If the two values differ, the corresponding off-diagonal term is incremented. Once the confusion matrix has been completely determined, the simple accuracy, the weighted accuracy, the kappa coefficient, and Brennan and Prediger's kappa are calculated and the interface is updated. The confusion matrix along with the four figures of classification accuracy are written to the disk file. A sample output file follows in Figure 5.5.3.

This	19	the	confusion	matrix.

262050	642	332	1	64
76	91922	4	81	0
173	861	32463	35	121
180	1430	252	16564	1292
170	0	0	0	9363

170 0 0 0 9363 The simple accuracy = 0.986097The weighted accuracy = 0.961072The kappa coefficient = 0.974530Brennan and Prediger's kappa coefficient = 0.982621

Figure 5.5.3- Sample output from the Confusion Matrix module

6.0 Image Classification Comparison

The color plates in Figures 6.0.1 through 6.0.4 are the test images for the various classification algorithms. The images include a range of class types from rural agricultural settings to densely populated urban scenes. All 6-band multispectral images. Three are from the M7 airborne sensor and the remaining image (Figure 6.0.3) is from the LANDSAT satellite. Table 6.0.1 below reports the important statistics of each scene.

Table 6.0.1 - Test image statistics

image name	size (H x V)	sensor	bands
city.lan	704 x 594	M7	3,6,8,10,12 & 13
landcover.lan	676 x 701	M7	3,6,8,10,12 & 13
roch84.lan	512 x 512	LANDSAT	1 - 5 & 7
seashore.lan	500 x 500	M7	3,6,8,10,12 & 13

Three major classification tasks were undertaken to compare the classification results derived from the varying approaches. In the following sections, the restrictions imposed upon and the desired goals of each task will be described. The procedure for how the images were classified, along with the elapsed time and accuracy measurements, will be presented for each algorithm accompanied by classification maps for visual inspection.



Figure 6.0.1 landcover.lan

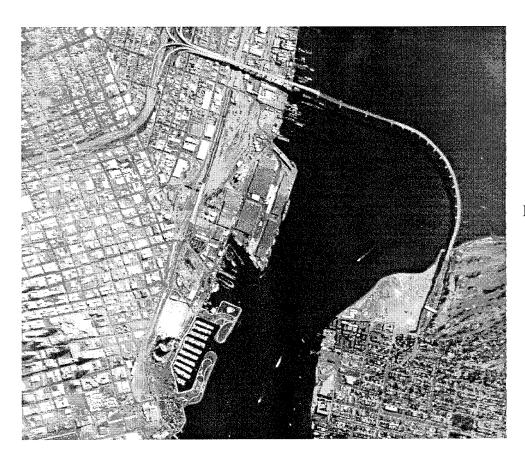


Figure 6.0.2 city.lan



Figure 6.0.3 roch84.lan

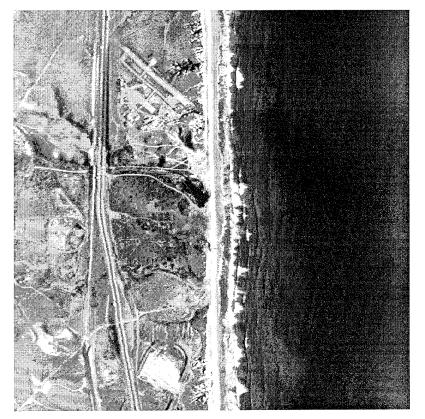


Figure 6.0.4 seashore.lan

6.1 Task 1: Discussion and Results

The first task undertaken in this study involved classifying approximately 95% of each image using training data collected from the fuzzy K-means algorithm. The goal of this task is to highlight the ability of each algorithm to classify broad target categories given trusted data for each class.

The cluster shift limit parameter of the fuzzy K-means module was set to four for all operations. This implies that all cluster centers must have moved less than a total of four pixels in the six-dimensional feature space before convergence can occur. The unsupervised classifier was set first to a large membership value, typically 0.9 or 0.85, to collect the trusted training data for each of the classifiers. The high membership value used to construct the training data was manipulated to ensure that there are at least 60D pixels per class, where D is the number of bands, to ensure valid statistical calculations. The clustering operation was repeated with the classifier reset to a lower membership value, typically 0.3 to 0.4, to form a truth image. The lower membership value was manipulated to ensure that approximately 95% of the image was classified. The value for the number of cluster centers was estimated from visual inspection. Recall that the cluster centers are initially selected in a pseudorandom manner. This ensures that the same cluster centers will be found regardless of membership value. Utilizing the fuzzy K-means clustering algorithm with a low membership value provides an easy method to construct truth images for comparison purposes. The use of the algorithm to produce truth images can be justified by realizing that this approach produces cluster centers, and the ensuing classification is based entirely upon naturally occurring "clumps" of pixels in feature space. The resulting truth images also support visual intuition of class membership and extent. The results of the clustering operation are summarized in Table 6.1.1.

Table 6.1.1 - Fuzzy K-means clustering statistics

image name	number of cluster centers	membership values	number of iterations	elapsed time (sec)
city.lan	6	0.9 & 0.3	17	2,442
landcover.lan	6	0.9 & 0.3	7	1,362
roch84.lan	5	0.85 & 0.3	6	635
seashore.lan	5	0.85 & 0.4	5	490

As expected, locating clusters of pixels within a multispectral image is computationally intensive. The wide distribution of both elapsed time, and the related value for the number of iterations to reach convergence, is a function of image size, complexity or content, and desired number of cluster centers. The reported elapsed time is the result of averaging numerous clustering operations, but very low variation was observed.

After constructing both training data sets and truth images, image classification was readily accomplished. For GML classification, the training data from the clustering algorithm must first be operated upon to construct the parametric model of the data which is stored in a statistics file. The detailed statistics files for each training set can be found in appendix B. Table 6.1.2 summarizes the number of classes in each training set, the number of points in each training set, and the elapsed time to create the statistics file for each training set. Note that required time to create the statistics file depends upon both the number of classes and the number of points in each training set.

Table 6.1.2 - Summary of GML statistics file parameters

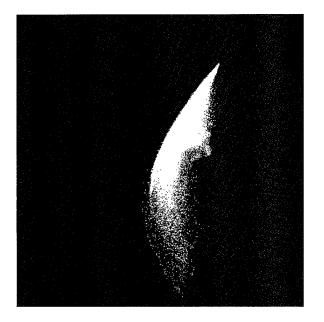
image name	number of classes	number of points in training set (sec)	elapsed time to create statistics file (sec)
city.lan	6	150,874	11
landcover.la79n	6	44,791	3
roch84.lan	5	27,177	2
seashore.lan	5	124,851	7

With a mathematical model that describes the distribution of the training data constructed, image classification with GML is a straightforward process. The value of chi squared (χ^2) was manipulated until the target classification percentage of 95% was achieved. Note that the large values of the χ^2 distance can be explained by realizing that the training data was collected at a high membership value. As such, it is tightly clustered in feature space. The large value of this distance parameter permits the resulting hyperellipsoids to expand to encompass the size of all classes. The reported classification accuracy is the simple accuracy, and the truth image for comparison purposes was created with the fuzzy K-means algorithm. Complete confusion matrices for each of the images are available for detailed inspection in appendix B. The GML classification results are summarized in Table 6.1.3.

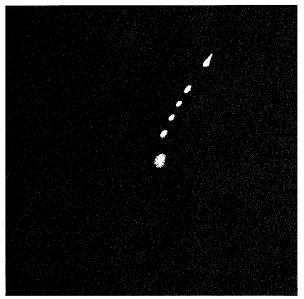
Table 6.1.3 - Summary of GML classification statistics

image name	value of χ^2	elapsed classification time (sec)	percentage of image classified	classification accuracy
city.lan	256	60	94.86	88
landcover.lan	350	61	95.1	85
roch84.lan	160	29	95.53	86
seashore.lan	145	27	95.9	90

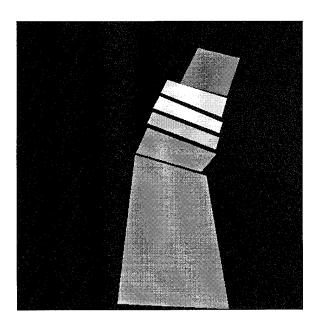
The images were classified next with the nPDF algorithm utilizing the same training data. The training data was first projected in varying nPDF spaces until no clusters overlapped, or until any such overlap was minimized. Recall that nPDF space is determined by both a hypercube corner pair and scale factor selection. The original image was then projected utilizing the same parameters so that the extent of each class in the projected space could be determined. This information was then used to build the classification LUT. This process is depicted in Figure 6.1.1 through 6.1.4.



nPDF projection of city image



nPDF projection of city training data

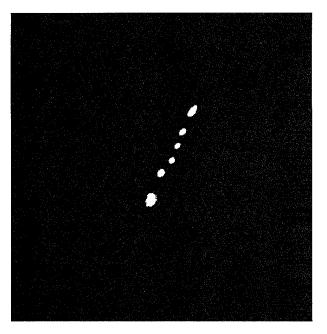


LUT created from training data

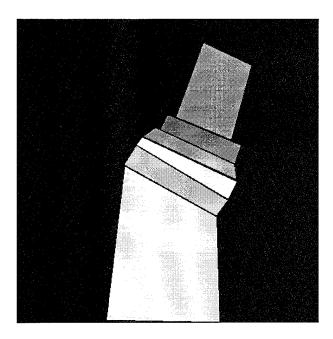
Figure 6.1.1 - nPDF development for the city.lan image



nPDF projection of landcover image

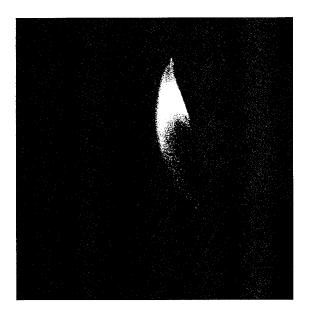


nPDF projection of landcover training data

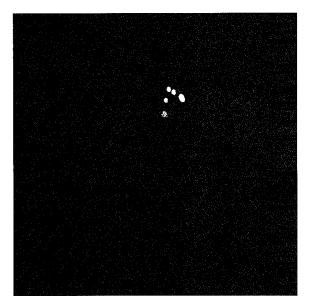


LUT created from training data

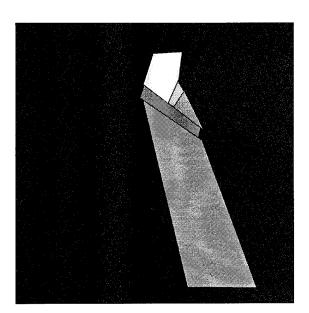
Figure 6.1.2 - nPDF development for the landcover.lan image



nPDF projection of rochester image

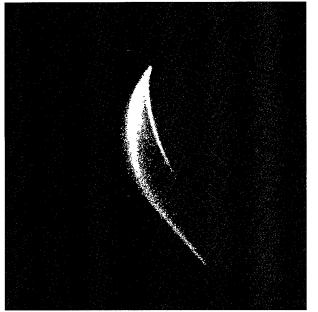


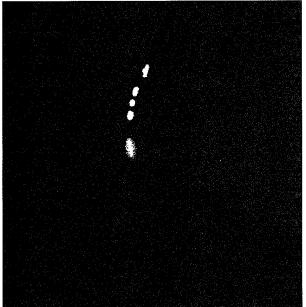
nPDF projection of rochester training data



LUT created from training data

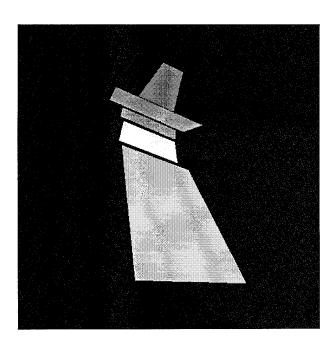
Figure 6.1.3 - nPDF development for the roch84.lan image





nPDF projection of seashore image

nPDF projection of seashore training data



LUT created from training data

Figure 6.1.3 - nPDF development for the seashore.lan image

The important nPDF LUT creation statistics are summarized in Table 6.1.4.

Table 6.1.4 - Summary of nPDF LUT statistics

image name	hypercube corners	scale factor	projection time for training data (sec)	projection time for image (sec)
city.lan	1 & 4	512	15	51
landcover.lan	1 & 4	512	4	59
roch84.lan	1 & 2	1,024	6	35
seashore.lan	1 & 3	512	14	32

Note that the elapsed time is determined by the number of pixels in the image or training set. The number of data classes has no effect on the either the projection or classification time, but it does make constructing the LUT more difficult and time consuming. In addition, it is important to note that the only LANDSAT image in the test group required the largest scale factor, and (as we shall see) has the lowest classification accuracy. The reason is the fixed gain of the LANDSAT TM sensor, which does not effectively utilize the available dynamic range of digital count values, while the exposure control of the M7 sensor does so. LANDSAT TM images will therefore always have lower dynamic ranges than comparable M7 images. In nPDF projection space, this will manifest itself as more densely packed class clusters. In turn, this forces larger scale factor values to drive the class clusters apart. Since the class clusters are closer together, any errors in the LUT that designates boundaries between the classes will lead to larger classification error and lower classification accuracy. The images were then classified with the LUTs and associated parameters just described. Reported classification accuracies reflect the simple accuracy metric with respect to the fuzzy K-means derived truth image. Table 6.1.5 summarizes the important classification parameters.

Table 6.1.5 - Summary of nPDF classification statistics

image name	elapsed classification time (sec)	percentage of image classified	classification accuracy
city.lan	53	95	88
landcover.lan	56	93	78
roch84.lan	34	91	70
seashore.lan	31	93	86

Note that it was not possible to achieve the target image classification percentage in all cases with this classification approach. This is due to the fact that it is very difficult to construct LUTs with boundaries that perfectly adjoin without overlap. Any spacing between class polygon regions results in pixels that should have been assigned to a class being improperly relegated to the background. Relatively low classification accuracies can be attributed to the inherent data dimensionality reduction of the nPDF projection operation. In moving from six- to two-dimensional space, information is irretrievably lost which leads to lower classification accuracies.

The images were then classified with the fuzzy ARTMAP neural network utilizing the same training data as the previous classification methods. As with the GML approach, the neural network must construct a mathematical model of the data. Note that the elapsed time to create the neural network depends upon the value of the vigilance parameter ρ , the number of training points and their variance, the number of training classes, and the resulting number of classification nodes created. This statement may not be readily evident, but it is easily explained. As the algorithm is creating the artificial neural network, it must evaluate the membership of each training exemplar in the training set with respect to each of the classification nodes. As the number of classification nodes created increases (recall that this number is driven by the variance of the training set and the value of ρ), more and more sets of calculations are needed for each training exemplar.

The value of ρ was adjusted to achieve the target classification percentage of 95%. Increasing the vigilance parameter would have produced a smaller hyper-rectangle in feature space leading to more accurate classification, but this would have occurred at the expense of classifying less of the input image. The fuzzy ARTMAP network creation statistics are summarized in Table 6.1.6.

Table 6.1.6 - Summary of fuzzy ARTMAP network statistics

image name	ρ for ART _a	number of ART _a nodes	number of learning iterations	elapsed time to create network (sec)
city.lan	0.88	6	2	51
landcover.lan	0.91	6	2	16
roch84.lan	0.91	5	2	8
seashore.lan	0.9	12	3	72

Once each neural network has been constructed, the images were classified. All values in the associated parameter files were identical with the exception of the size of the training set, the number of classification nodes, the number of target classes, and the value of the minimum vigilance parameter. Resulting classification time is affected by the image size and the number of classification nodes in the neural network. This is most evident in the seashore.lan image test case. Though the image is the smallest test image, the combination of the variance of the training classes and value of the vigilance parameter lead to the creation of multiple classification nodes for each class. This leads to the largest elapsed time for network creation and image classification. As the image is classified, each pixel must have its membership evaluated for each classification node. As expected, this can greatly increase classification time. Table 6.1.7 summarizes the performance of fuzzy ARTMAP image classification. The accuracy value reported is the simple accuracy with respect to the truth image created by the fuzzy K-means algorithm.

Table 6.1.7 - Summary of fuzzy ARTMAP classification statistics

image name	elapsed time to classify image (sec)	percentage of image classified	classification accuracy
city.lan	41	97	91
landcover.lan	46	96	89
roch84.lan	28	96	90
seashore.lan	46	96	93

For comparison purposes, Table 6.1.8 summarizes the classification times and accuracies for the different classification algorithms. The classification time for the GML approach reflects the sum of the time required to make the statistics file and classify the image. Similarly the time reported for the fuzzy ARTMAP approach reflects the time required to create the neural network and classify the image. The reported time for the nPDF classification approach reflects the sum of the time to project the training data and the original image. The time required to create the LUT is not reported. This procedure should not be rushed as classification accuracy is wholly dependent upon it. It can be realistically estimated to require approximately 20 minutes to construct a five- or six-class nPDF LUT.

Table 6.1.8 - Summary of classification times and accuracies

image name	GML time (sec)	GML accuracy	nPDF time (sec)	nPDF accuracy	ARTMAP time (sec)	ARTMAP accuracy
city.lan	71	88	104	88	92	91
landcover.lan	67	85	115	78	62	89
roch84.lan	31	86	71	70	36	90
seashore.lan	40	90	63	86	118	93

To aid in comparison, Figure 6.1.5 graphically displays the classification accuracy and Figure 6.1.6 depicts the required image classification time.

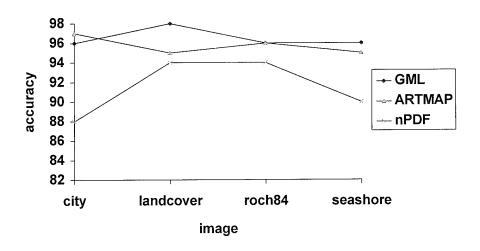


Figure 6.1.5 - Plot of task 1 classification accuracies

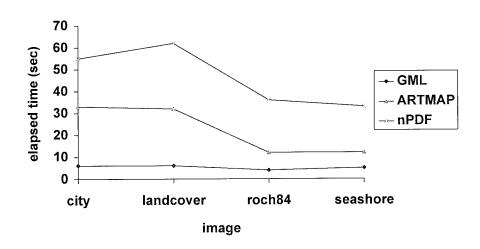


Figure 6.1.6 - Plot of task 1 elapsed classification times

Figure 6.1.7 was formed by computing the ratio of the classification accuracies to the required training/classification time. The objective of this plot is to visualize the performance of each algorithm with respect to accuracy and required classification time.

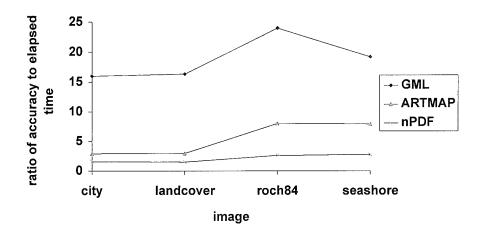


Figure 6.1.7 - Plot of task 1 ratio of accuracy to classification time

Note that the fuzzy ARTMAP classifier consistently produced the greatest classification accuracy. When the number of ART_a classification nodes equaled the number of classes of data, the algorithm's classification time is favorably comparable to that of the GML. When the vigilance parameter is increased, or there is great variation in the data, its performance suffers due to the number of calculations that must be performed on each individual pixel. The nPDF algorithm consistently produced the lowest classification accuracies coupled with the greatest classification/training time. This can be attributed to the inherent smearing and loss of data present in any projection technique. This approach is not without merit. Its greatest strength lies in its data visualization properties.

A variety of classification metrics were developed for this study. The various metrics were graphed for each image. This graph is present in appendix C. For this task,

the classification accuracy metrics were consistently found to be ordered with simple accuracy first, Brennan and Prediger's Kappa, followed by the standard kappa coefficient. For this reason, only the simple accuracy metric was reported.

The color plates in Figure 6.1.8 through 6.1.11 depict the classification maps for each image and each classification methodology. All colormaps are encoded in the same manner. Class 1 is red, class 2 is blue, class 3 is green, class 4 is purple, class 5 is yellow, and class 6 is cyan. In this way the output from the class statistics module can be visually coupled with class statistics information.



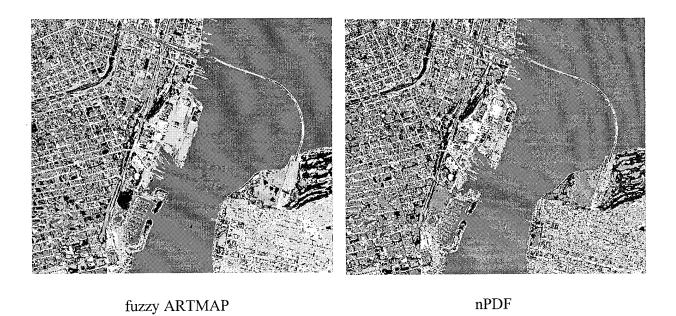


Figure 6.1.8 - task 1 classification maps for the city.lan image

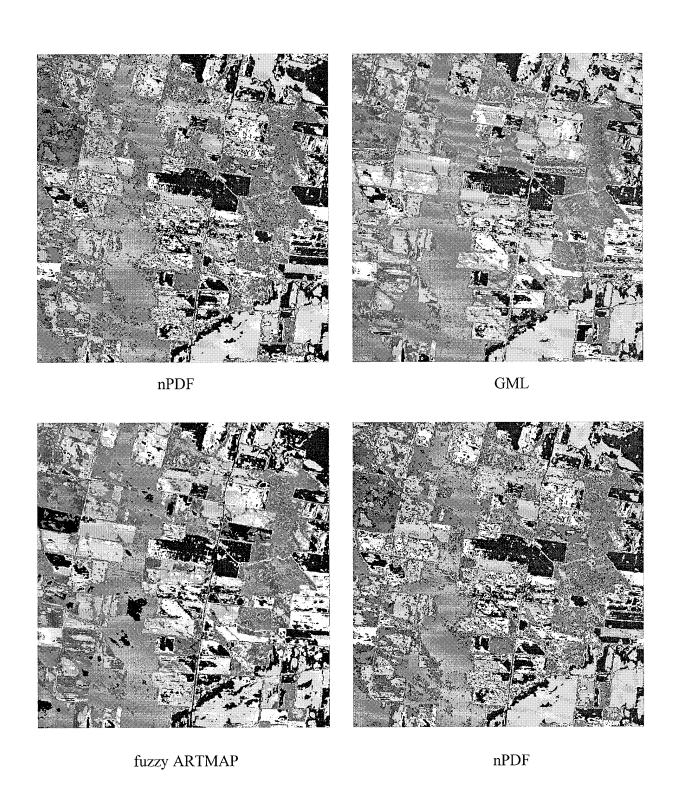


Figure 6.1.9 - task 1 classification maps for the landcover.lan image

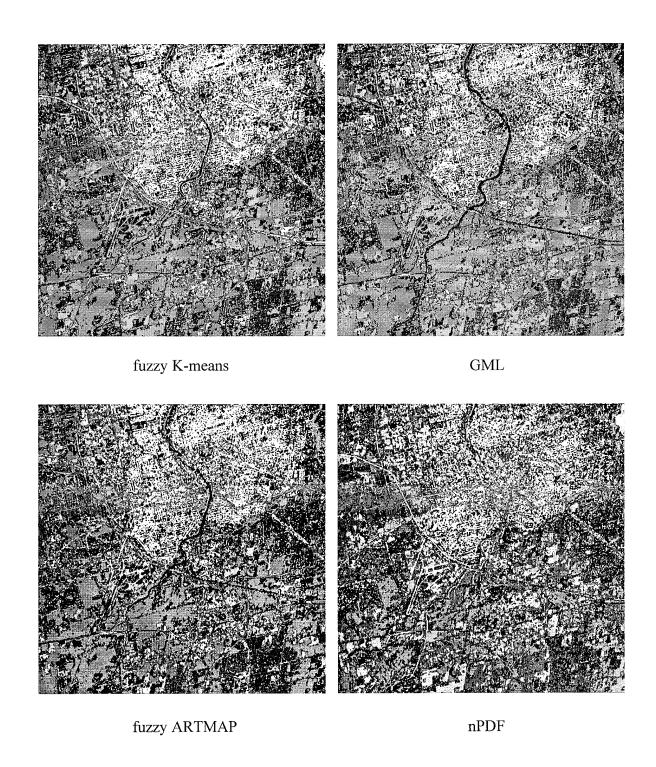


Figure 6.1.10 - task 1 classification maps for the roch84.lan image

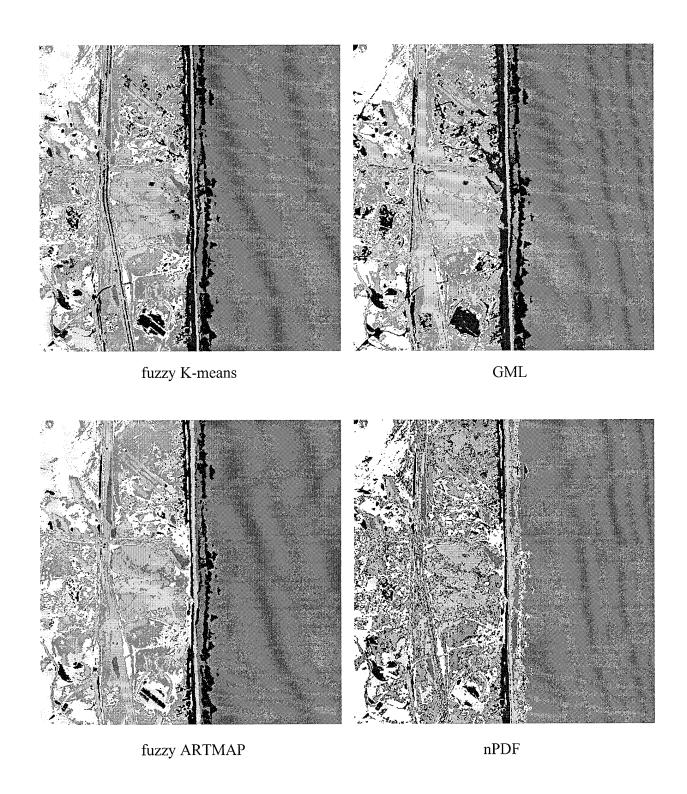


Figure 6.1.11 - task 1 classification maps for the seashore.lan image

6.2 Task 2: Hybrid Classification Discussion and Results

Task two of this study utilized a hybrid classification methodology. In this scheme, the input image is first segmented to produce an image composed of tightly clustered data, and this image is then classified. The nPDF algorithm was used to segment the city.lan and landcover.lan images. The water class from the city image and two tightly intermingled vegetation classes from the landcover image were used to create a segmented image comprised of just the classes of interest. These segmented images were then processed by the fuzzy K-means algorithm to form trusted training classes and truth images with the method described in section 6.1 of this report. The training data for the images were passed to the GML and fuzzy ARTMAP classifiers where the segmented image was classified by each algorithm. Note that since numerous classes were made from tightly clustered data, the resulting training class sets will have mean vectors in close proximity to each other. The goals for this task were to experiment with hybrid classification, classify more than 95% of the segmented image, and to test the performance of the algorithms when operating upon data that is not well separated in feature space.

The hybrid classification methodology should produce higher classification accuracies and lower elapsed times. This observation is partly due to the fact that only a portion of the image needs to be processed. Because of this, classification times will be reduced. The "skip zero vectors" features of the classifier modules will be used to support this operation. In addition, little extraneous data is passed to the classification stage from the segmentation phase. Decreased misclassification will be observed in both algorithms due to the great reduction of extraneous data. As such, the subsequent classification algorithms can "concentrate" on the detailed classification task at hand.

As previously stated in the introduction, the nPDF algorithm was used first to segment the city and landcover images to form the city_water and seg_landcover multispectral images. This algorithm is most appropriate for the segmentation task as it lends itself to situations where class separation is large and classification accuracy is not paramount. This statement can be readily reinforced by reviewing the performance of the algorithm in task one. Select portions of the LUTs used in this task were reused to create the segmentation LUTs. In an image segmentation mode, the nPDF algorithm functions similarly to that used in a classification role with one important difference. Instead of producing a classification map, this operation produces a new multispectral image composed of pixels that fall within the classification boundaries of the LUT in the projected feature space. Any pixels that did not fall within the boundaries of the LUT classification regions were assigned zero vectors in the resulting output images. Figure 6.2.1 on the following page depicts the nPDF approach to image segmentation and Table 6.2.1 highlights the important statistics for the segmentation operation.

Table 6.2.1 - nPDF segmentation statistics

image name	hypercube corners	scale factor	segmentation time for image (sec)	percentage of image segmented
city_water.lan	1 & 4	512	54	37.1
seg_landcover.lan	1 & 4	512	57	39.5

The resulting segmented images were then clustered with the fuzzy K-means algorithm to create truth images and training data. Once again, the high membership value was manipulated to ensure statistically sound training sets. Similarly, the low membership value was varied to classify the vast majority of the image to form a truth image. The important parameter from the clustering operation are summarized in Table 6.2.2.

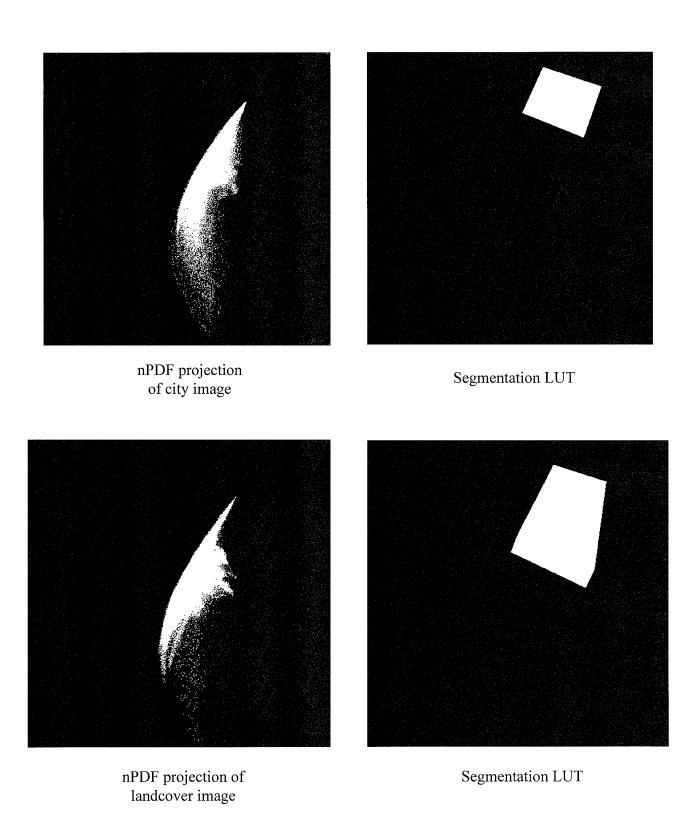


Figure 6.2.12 - nPDF segmentation LUT development

Table 6.2.2 - Clustering statistics for hybrid classification

image name	number of cluster centers	membership values	number of iterations	elapsed time (sec)	percentage of image classified
city_water.lan	4	0.85 & 0.3	12	711	37.1
seg_landcover.lan	5	0.85 & 0.3	12	1,041	39.5

Once the training data was obtained, a parametric model of the data was constructed for the GML classifier. Table 6.2.3 summarizes the number of pixels in each set, the number of classes in each training set and the time required to calculate the mean vectors, the inverses of the variance-covariance matrices, and their determinants.

Table 6.2.3 - Training class statistics for hybrid GML classification

image name	number of classes	number of points in training set	elapsed time to create statistics file (sec)
city_water.lan	4	52,458	3
seg_landcover.lan	5	22,788	2

With a parametric model describing the distribution of the data, GML classification was readily accomplished. The value of χ^2 was manipulated to achieve the target image classification percentage value of 95%. A percentage less than 100% was utilized to provide a fair comparison between the performance of the two classifiers. This was accomplished by forcing both the neural network and the GML classifier to discriminate the outlying data elements. If 100% classification had been used instead, the GML approach would have suffered from errors due to improper inclusion of pixels in a class due to large χ^2 distances. Similarly, the run-time performance of the ARTMAP classifier would have been artificially enhanced due to the ARTMAP's attempt to maximize its generalization of feature space division. Fewer recognition regions require fewer weight

vectors to describe them and fewer calculations on each image pixel. The fuzzy ARTMAP was forced to minimize its generalization of feature space by utilizing high values for the vigilance parameter. The reported classification accuracy metric is the simple accuracy, and it is created with respect to the truth image created with the fuzzy K-means approach. Important classification results are summarized in Table 6.2.4.

Table 6.2.4 - Hybrid GML classification results

image name	value of χ^2	elapsed classification time (sec)	percentage of image classified	classification accuracy
city_water.lan	65	15	95.6	93
seg_landcover.lan	90	26	95.2	92

Note that the values of the χ^2 distance are considerably smaller than the values that were utilized in task one. This can be readily explained by realizing that the data is tightly clustered in feature space and has considerably lower spectral extent. As such, GML's hyperelliptical classification regions need only increase a moderate amount to accomplish the desired percentage of image classification. Note that the reported value is with respect to the portion of the segmented image composed of non-zero pixel intensity vectors.

Classification with the fuzzy ARTMAP algorithm was then accomplished utilizing the same training data as for the GML approach. Since the training data is tightly clustered in feature space and having small spectral extent, high values of the vigilance parameter ρ were necessary to achieve the percentage of image classification desired. As expected, a large value for the vigilance parameter produces a neural network with finely granulized feature space recognition regions. Recall that each classification region is defined by the weight vector of a node. In this case, multiple nodes were needed to encompass the spectral extent of the target classes. Table 6.2.5 summarizes the important training statistics.

Table 6.2.5 - Hybrid fuzzy ARTMAP network statistics

image name	ρ for ART _a	number of ART _a nodes	number of learning iterations	elapsed time to create network (sec)
city_water.lan	0.97	9	2	15
seg_landcover.lan	0.94	10	2	8

Once the neural network was created, image classification was easily accomplished. Rapid image classification was realized because only the non-zero pixel intensity vectors must be evaluated. The reported accuracy metric is the simple accuracy with respect to the fuzzy K-means truth image. Important classification statistics are presented in Table 6.2.6 below.

Table 6.2.6 - Hybrid fuzzy ARTMAP classification results

image name	elapsed time to classify image (sec)	percentage of image classified	classification accuracy
city_water.lan	22	95.1	97
seg_landcover.lan	29	94.1	95

Table 6.2.7 summarizes the hybrid classification results. The times for the GML approach reflect the image segmentation operation, class statistics determination, and image classification elapsed times. Similarly, the reported elapsed times for the hybrid ARTMAP approach is the sum of the image segmentation, network creation, and image classification operations.

Table 6.2.7 - Summary of hybrid classification results

image name	hybrid GML time (sec)	hybrid GML accuracy	hybrid ARTMAP time (sec)	hybrid ARTMAP accuracy
city_water.lan	72	93	91	97
seg_landcover.lan	85	92	94	95

Figure 6.2.2 graphically depicts the simple accuracy measurements for the city water and the seg landcover images classification results.

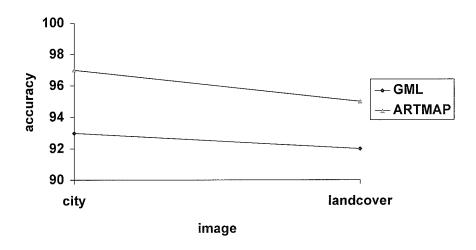


Figure 6.2.2 - task 2 image classification accuracy results

Figure 6.2.3 depicts the required classification times. Note that the reported time figure is the sum of the image segmentation, data modeling or network creation, and classification operations.

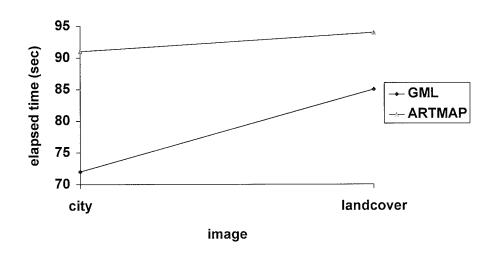


Figure 6.2.3 - elapsed time for hybrid image classification

Figure 6.2.4 was formed by computing the ratio of the classification accuracy to the required classification time.

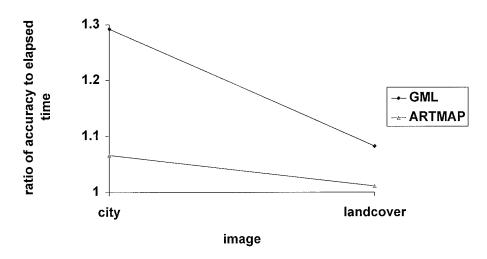


Figure 6.2.4 - ratio of classification accuray to elapsed time for hybrid image classification

As was the case in task 1, the fuzzy ARTMAP approach produced the best accuracy, but at the cost of greater processing time than the GML approach. The effect of minimized class separation is partly the cause of this observation. It is interesting to note that the training data for the classifiers were projected into nPDF space and classification in all cases would have been difficult if not impossible with this methodology. The training data also is not necessarily distributed in a multivariate normal manner. For these reasons, the non-parametric approach may have some inherent advantage. Note that in this case, as in task 1, the training data was collected by the fuzzy K-means algorithm. The ARTMAP benefits from this as a spectrally pure closely clustered data set is presented for training. As such, it is able to create a relatively small number of recognition regions in feature space that provide for the conflicting needs of within-class generalization while providing between-class distinction. While the GML

approach inherently minimizes the effect of spurious training exemplars through the creation of the variance covariance matrix, the neural network employed in this study enjoys no such luxury. The GML approach does not greatly benefit from the spectrally pure training data because outlying data is automatically averaged out. Also note that, if the training data was collected at a very high membership value, then the training data may be spectrally colored by the mathematical processes employed by the training data collection process. This could distort the class orientation information and lead to poor classification. This effect was minimized by ensuring that the membership value produced a training set composed of a statistically significant number of values. Task 3 will explore the performance of these algorithms on user-defined data sets. These data will better describe the spectral extent of a class in feature space at the cost of necessarily including some "impure" training data.

All classification accuracy measures were reported with the simple accuracy measure. As was the case in task one, the values were always found to be in the same order with the exception of the weighted accuracy which attempts to account for size of each class. A graph comparing the various metrics is presented in appendix B.

Figures 6.2.5 and 6.2.6 represent the classification maps produced in this task. They are color coded to the information in the confusion matrices or class statistics files to support visual inspection. Class one is red, class 2 is green, class 3 is blue, class 4 is purple, class 5 is yellow, and class six is cyan.



fuzzy K-means



fuzzy ARTMAP



GML

Figure 6.2.5 Hybrid image classification results for a vegetation class in the landcover.lan image



fuzzy K-means

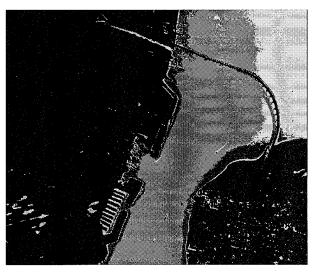




Figure 6.2.6 Hybrid image classification results for the water class in the city.lan image

6.3 Task 3 Results and Discussion

The goal of task 3 was to evaluate the performance of the various classifiers when trained and evaluated with user-defined data. The training data were collected for the algorithms by utilizing the user-interactive module. Truth images were constructed by designating polygons representative of the training classes within the images from which the training data were collected. The individual polygons were then segmented from the image to form an evaluation and truth image. The AVS procedure in Figure 6.3.1 was utilized to create the segmented image and truth image.

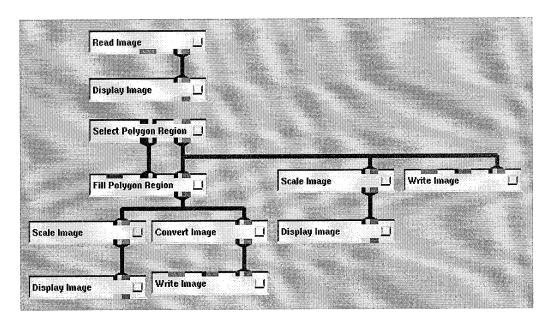


Figure 6.3.1 - AVS network to create evaluation polygons and truth images

This network reads in an multispectral image, displays it, and then permits polygon regions to be overlaid to define the evaluation polygons. This operation is supported by the *Select Polygon Region* AVS module. The multispectral data within the polygons is then passed to the rest of the network. Two important operations then occur in parallel. In the first operation, the multispectral data from the polygons are written to disk files as

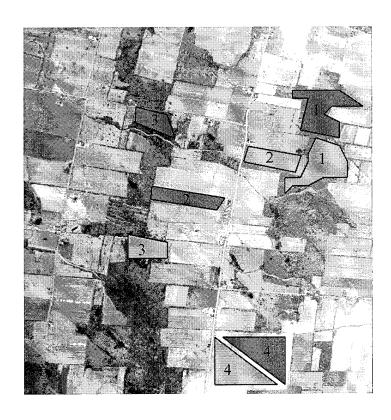
individual images. These individual images are later combined into an evaluation image with the network used to combine nPDF LUTs. In a similar fashion, the polygons are passed onto the *Fill Polygon Region* module where they are filled with the class number. These polygons are written to disk and combined to form a truth image to support measurements of classification accuracy. Figures 6.3.2 through 6.3.5 graphically depict the training and evaluation polygons used for each class in each image. To aid in interpretation, training polygons are colored blue while evaluation polygons are filled with red.

Care was taken during the collection of training data to ensure that statistically significant numbers of points were included in each training class. Once the training data was collected, image classification proceeded as previously described. The first step in the GML process was the creation of the class statistics files. Table 6.3.1 summarizes the important statistics from this process and detailed statistics for each of image are presented in appendix B.

Table 6.3.1 - Summary of GML statistics file parameters

image name	number of classes	number of points in training set (sec)	elapsed time to create statistics file (sec)
city.lan	5	17,502	2
landcover.lan	4	15,422	2
roch84.lan	3	4,407	1
seashore.lan	5	9,588	1

After the statistics files have been created, GML classification was readily accomplished. Since the image being classified was segmented to support evaluation, the skip zero vectors option was employed when using the AVS modules. Table 6.3.2 summarizes the classification parameters and statistics.





training polygon



evaluation polygon

Figure 6.3.2 landcover.lan

1 = scrub

2 =vegetation

3 = trees

4 =bare soil



Figure 6.3.3 city.lan

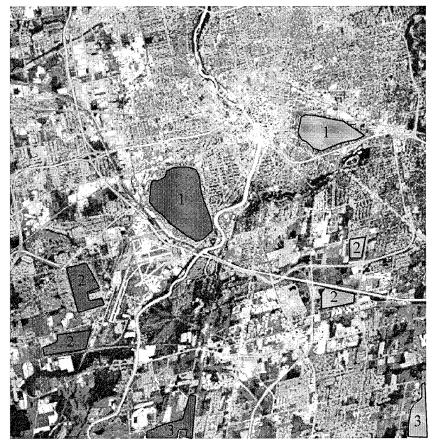
1 = water

2 = scrub

3 =bare soil

4 = roof

5 = asphalt



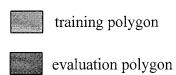


Figure 6.3.4 roch84.lan

1 = urban

2 = vegetation 3 = soil

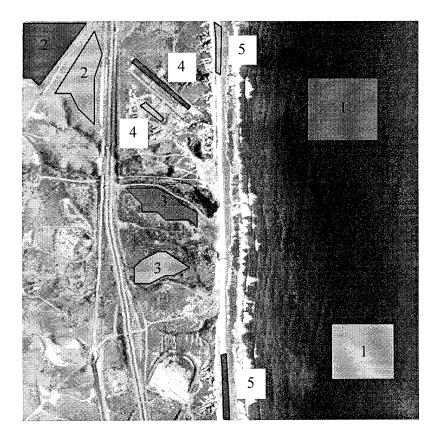


Figure 6.3.5 seashore.lan

1 = water

2 = grass 3 = scrub

4 = concrete

5 = sand

Table 6.3.2 - Summary of GML classification statistics

image name	value of χ^2	elapsed classification time (sec)	percentage of image classified	training accuracy	classification accuracy
city.lan	90	4	99	100	96
landcover.lan	100	5	99	96	98
roch84.lan	50	3	99	98	96
seashore.lan	50	4	99	98	96

The variance of the values of the χ^2 distance should be expected. The different classes in the user-defined training data vary in spectral extent in feature space. Its value was manipulated until 99% of the image would be classified with few pixels being assigned to the background class. The training accuracy metrics in the table represents the performance of the classifier on the training data. The classification accuracy metric is the simple accuracy and all detailed confusion matrices are in appendix B.

Image classification with the nPDF algorithm was accomplished next. The training data collected by the user interactive module was projected into different nPDF spaces until minimal class overlap was observed. Table 6.3.3 summarizes the parameters used and the elapsed time required to project the training data.

Table 6.3.3 - Summary of nPDF LUT statistics

image name	hypercube corners	scale factor	projection time for training data (sec)	projection time for image (sec)
city.lan	3 & 4	512	4	51
landcover.lan	1 & 2	512	3	59
roch84.lan	1 & 4	800	1	35
seashore.lan	1 & 3	512	1	32

LUTs were then constructed from the information in the projected training data. Figure 6.3.6 depicts the projected training data and the resulting LUT for visual inspection.

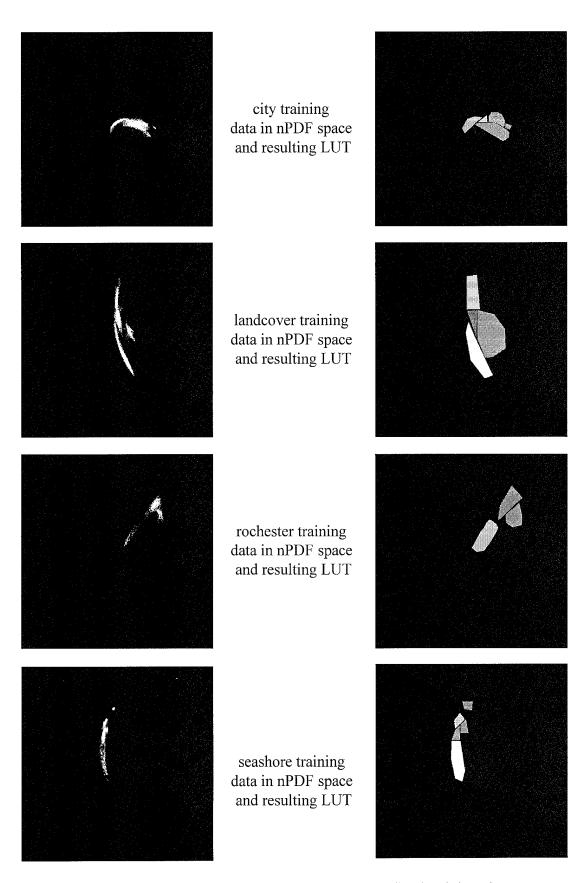


Figure 6.3.6 - nPDF development for the user defined training classes

The LUTs created from the user-defined data proved to be the most difficult to generate. This problem stems from the fact that some training classes had a relatively small number of pixels and there was considerable variance in some of the training data. This made determining classification boundaries a difficult and iterative process. Once the LUTs were constructed, nPDF classification was performed. The important statistics from the nPDF classification operation are summarized in Table 6.3.4 below.

Table 6.3.4 - Summary of nPDF classification statistics

image name	elapsed classification time (sec)	percentage of image classified	training accuracy	classification accuracy
city.lan	3	96	90	88
landcover.lan	7	97	95	94
roch84.lan	2	97	93	94
seashore.lan	3	98	91	90

Note that it was not possible to achieve the desired percentage of image classification. Once again, this is due to the fact that it is very difficult to draw classification boundaries that do not overlap. This same problem is the cause of the relatively low classification accuracy on both the dependent training used in the LUT creation and the independent data that the classification accuracy was evaluated upon.

The same data used with the GML and the nPDF approach were then utilized to train the fuzzy ARTMAP neural network. The value of the vigilance parameter was adjusted to achieve the desired level of image classification. Table 6.3.5 summarizes the network parameters, number of learning iterations, and the elapsed time required to create the networks.

Table 6.3.5 - Summary of fuzzy ARTMAP network statistics

image name	ρ for ART _a	number of ART _a nodes	number of learning iterations	elapsed time to create network (sec)
city.lan	0.91	45	2	15
landcover.lan	0.9	40	3	19
roch84.lan	0.92	58	2	5
seashore.lan	0.92	28	2	6

With the networks created, image classification was then achieved. Table 6.3.6 summarizes the resulting accuracy measurements and the elapsed time required. The training accuracy metric relates the performance of the neural networks on the training data. In all cases, training was stopped once full recognition of the training data was achieved. Note that the accuracy measurement is the simple accuracy and is measured with respect to the truth image.

Table 6.3.6 - Summary of fuzzy ARTMAP classification statistics

image name	elapsed time to classify image (sec)	percentage of image classified	training accuracy	classification accuracy	
city.lan	18	99		97	
landcover.lan	13	99	100	95	
roch84.lan	7	99	100	96	
seashore.lan	6	99	100	95	

Table 6.3.7 summarizes the classification accuracies and elapsed times.

Table 6.3.7 - Summary of classification times and accuracies

image name	GML time (sec)	GML accuracy	nPDF time (sec)	nPDF accuracy	ARTMAP time (sec)	ARTMAP accuracy
city.lan	6	96	55	88	33	97
landcover.lan	6	98	62	94	32	95
roch84.lan	4	96	36	94	12	96
seashore.lan	5	96	33	90	12	95

Figures 6.3.7 and 6.3.8 below graphically depict the classification and elapsed computing time.

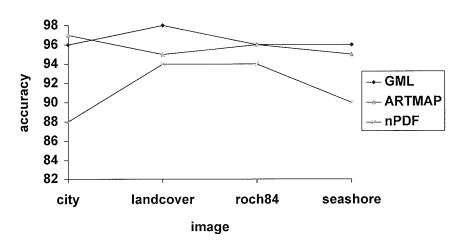


Figure 6.3.7 - Task 3 classification accuracies

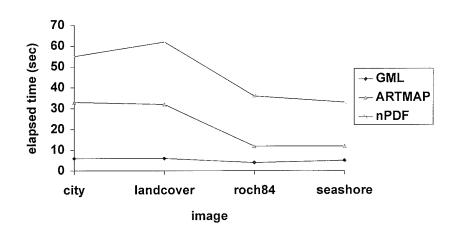


Figure 6.3.8 - Task 3 classification elapsed times

Figure 6.3.9 was created by computing the ratio of the classification accuracy to the required classification time.

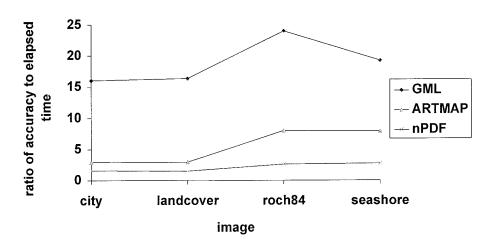
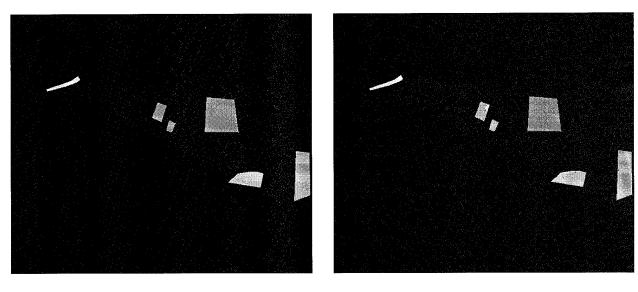


Figure 6.3.9 - Task 3 ratio of classification accuracy to classification time

The results of this task highlight the primary concern present when utilizing nonparametric classifiers. Note that in contrast to its performance in the other tasks, the GML classifier twice displayed better performance than the fuzzy ARTMAP classifier. The high classification accuracy performance of the GML classifier can be most easily attributed to the mathematical properties of the variance-covariance matrix. The matrix contains information about the shape of the training data distribution, its orientation in feature space, and its extent. As such, the parametric classifier has the ability to logically "fill in" missing data points, and the impact of noisy or spurious training data are automatically averaged out. In contrast, the classification performance of the nonparametric classifiers entirely depends on the quality of the training data, and they are inherently unable to account for missing information. Incomplete training data sets will always be encountered when the training data is interactively determined by the image analyst. Due to this reality, GML may represent the optimal image classification strategy when dealing with user-defined training data.

Classification maps from this task are depicted in Figures 6.3.8 through 6.3.11.



truth image GML

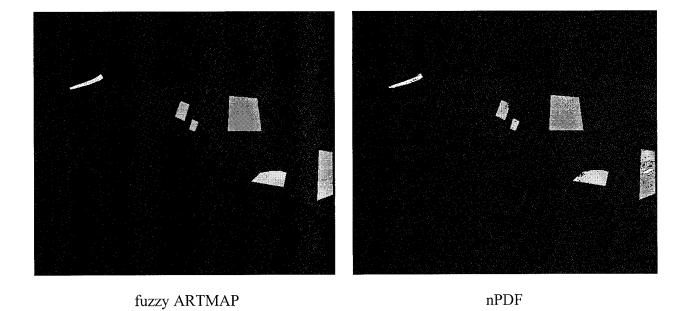


Figure 6.3.8 - task 3 classification maps for the city.lan image

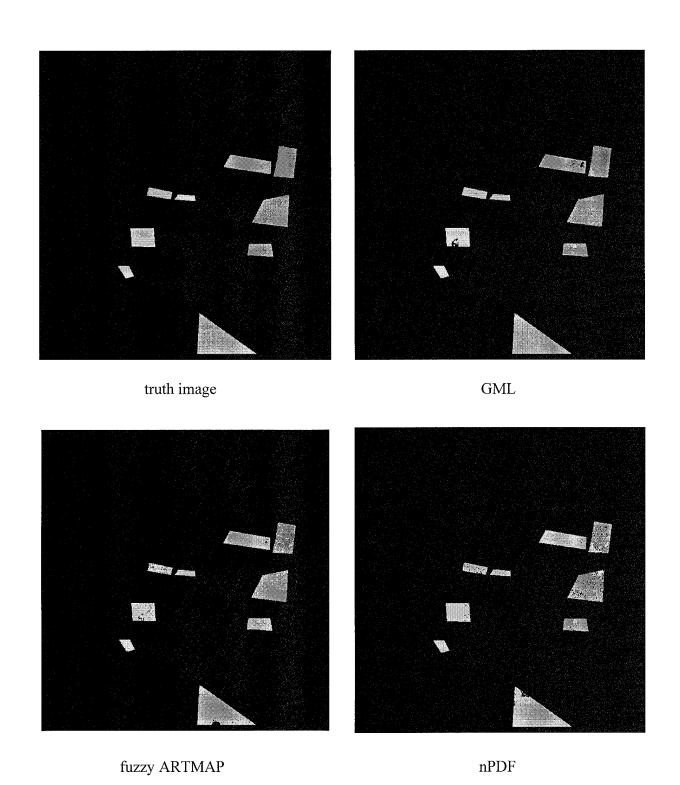


Figure 6.3.9 - task 3 classification maps for the landcover.lan image

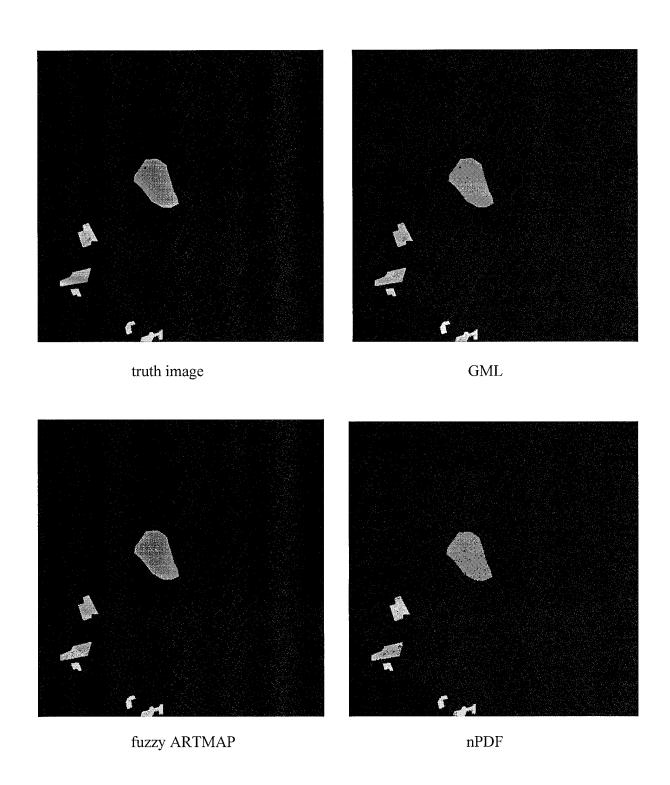


Figure 6.3.10 - task 3 classification maps for the roch84.lan image

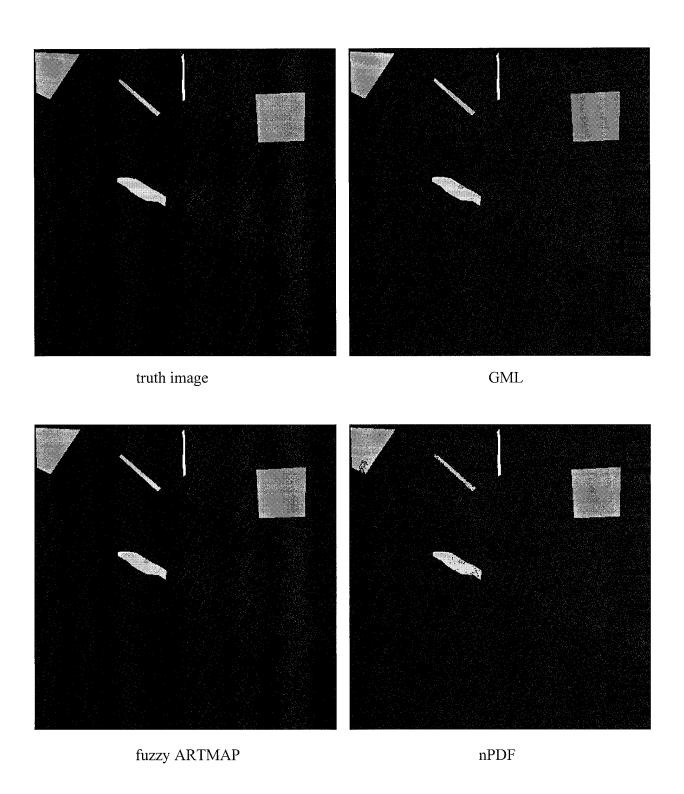


Figure 6.3.11 - task 3 classification maps for the seashore.lan image

7.0 Summary

The fuzzy K-means clustering algorithm was shown to be effective for both creating spectrally pure training data and truth images for measuring classification accuracy. This flexibility is gained by its employment of fuzzy logic through the membership function. Features within an image for which it is very difficult to collect training data, either due to size or sparse positioning, can be effectively sampled with this method. There are three main problems with this approach to image classification. First, the algorithm is extremely computationally intensive. This observation is easily explained by realizing that the membership of each pixel in the image with respect to each desired cluster center must be determined iteratively. Secondly, the clusters formed are computed in an entirely unsupervised manner and may be difficult to visually label. Finally, the data collection methodology inherently colors the training class data which destroys some class distribution information.

The heart of this study concerns itself with the manner in which each classification algorithm divides feature space into recognition regions. Gaussian maximum likelihood utilizes hyperellipsoids, the nPDF algorithm allows the analyst to define arbitrary boundaries in a projection of feature space, and the fuzzy ARTMAP neural network utilizes stacked hyper-rectangles with exception handling.

GML is the classical approach to multispectral image classification. This study has demonstrated that its classification accuracy and computational requirements on user-defined data are difficult to achieve by other methods, even an advanced neural network. The variance-covariance matrix at the core of the algorithm provides not only the location of the classes in feature space, but also a measure of their extent and orientation. In addition, the method used to calculate the variance-covariance matrix from the training data automatically weights the effects of both frequently occurring and outlying data points. Neither of the non-parametric classifiers addressed in this study are

able to accomplish this. The determination of class extent and orientation is achieved through the assumption of normally distributed pixels made when calculating the variance-covariance matrix which forms the core of its data dispersion model. The validity of the normality assumption was shown to come from the averaging effect of the sensor, and be a reasonable assumption in most remote sensing applications.

The nPDF approach to image classification was shown to uniquely involve the analyst in image classification. By interactively drawing class boundaries in a projection of feature space, subtle variations in class boundaries can be accounted for in a manner that is not possible algorithmically. It is important to note that outlying or mislabeled training data are handled in an extremely effective manner. Incorrect training data are automatically grouped into the correct class through the projection operation. This facet of the algorithm was exploited in the hybrid image classification task. The greatest strength of this algorithm is its data visualization properties as separability between classes can be readily interpreted. While class separability can be readily visually interpreted, defining accurate boundaries between the classes proved to be difficult. In addition, this method enjoys no real computational advantage in terms of elapsed time required to classify an image when compared to GML, once the time to project the original image to determine class extent is included. The introduction to this study mentioned that the nPDF algorithm could be potentially useful for determining the number of classes present in an image. This facet of the algorithm proved impossible to demonstrate with the LANDSAT or M-7 imagery used in this study. Had it been possible to achieve, distinct peaks in the nPDF projections of the images would have been noted.

Image classification with the fuzzy ARTMAP neural network produced intriguing results. When it is presented with the spectrally pure training data collected by the fuzzy K-means algorithm, its classification accuracy performance was shown to be unparalleled with only a slight increase in time required to train and classify the image as compared to

GML. This strength springs from the employment of fuzzy set theory and ART dynamics. No other neural network architecture so effectively combines these traits. When user-defined data is utilized with this approach, its greatest weaknesses are highlighted. Large variations in data coupled with cluster centers that are close to one another in feature space result in a neural network with many small hyper-rectangles dividing feature space into recognition regions. This case, which occurs often in the remote sensing application, springs from the attempt to achieve the conflicting goals of maximizing generalization while maintaining separability. This results in numerous computations being completed for each pixel in the image or training set. This manifests itself as increased learning and image classification times. If the network has not been presented with the examples of the complete spectral extent of a class, it is not capable of determining membership in the manner that GML is. Since the data distribution is not modeled, no mathematical inference other than the fuzzy "nearness" can be determined. While GML can determine that a pixel not explicitly encountered during training should "fit" in the distribution of one of its classes, the neural network cannot. It requires training sets composed of pixels that both are spectrally pure and that completely define the spectral extent of the classes in feature space.

The varying measurements of classification accuracy employed for this study were found to always follow the same pattern. The simple accuracy consistently provided the greatest measure of classification accuracy, followed by Brennan and Prediger's kappa, while the standard kappa coefficient always provided the worst measure of accuracy. The weighted accuracy, which attempted to account for class size, produced sporadic results. To compare the classification accuracy performance of the various algorithms, any measurement could be reported, and the simple accuracy was utilized in this study.

In general, it appears that the GML approach to multispectral image classification has not been "dethroned" by either of the non-parametric classifiers utilized in this study. The assumption of normal distributed training and target class data is reasonable. This assumption permits the algorithm to "fill in" missing data that was not present when the data dispersion model was created. Neither of the non-parametric classifiers observed in this study are able to accomplish this. Given robust spectrally pure training data, the fuzzy ARTMAP may provide slightly higher classification accuracies, but this comes at the expense of considerable complexity. Given classes that are readily spectrally separable, the nPDF algorithm produced reasonable results. In certain situations its performance may be optimal. In general, it is hampered by its inherent projection methodology.

The classification algorithms and methods employed in this study were evaluated under ideal "laboratory" conditions. As such, some comments on transitioning this system to an operational role are warranted. It is obvious that training each algorithm on each class in each image to be classified is overly time consuming. It would be desirable to train the classification algorithms on various target classes of interest and then be able to classify any given image. All of the classification algorithms rely on the digital count values present in an image to distinguish between classes. These digital count values are entirely dependent upon the imaging geometry and atmosphere present at image acquisition time. As such, some method must be employed to remove these effects. Typically these methods either model the contributions of the atmosphere at an imaging time, or more simply scale the digital count values present in one image to match those from the image from which the classifier was trained. As expected, there will be some loss of information or introduction of error when either of the preceding approaches are applied. Therefore, while classification results will not be as accurate as if the classifier

was trained with data from the image to be classified, considerable time will be saved by applying the previously determined classification models.

It is also interesting to note that the classification stage of each algorithm is inherently *parallelizable*. Any problem which can be readily divided and computed separately on multiple processors shares this quality. Since the classification results from the algorithms in this study depend only on the digital count values of the pixel in question, the classification operation can be easily divided across several processing units. This concept is easy to envision. Consider the case where we simply divide the input image by the number of available processors. The resulting subimages could then be classified by each processor and then recombined to form a classification map. As such, a very near linear decrease in classification elapsed time can be realized.

7.1 Suggestions for Future Work

It would be interesting to allow the user to select the starting cluster locations interactively for the fuzzy K-means algorithm instead of selecting them in a pseudorandom fashion. This would give the analyst some control of the resulting cluster centers and make labeling the resulting classes somewhat easier.

While the χ^2 distance measure of the GML classification algorithm allows the extent of classes to be controlled, no individual parameter for each class is provided other than the measure arising from the determinant of the variance-covariance matrix. If individual distance measures were employed, varying class extent in feature space could be controlled and compensated.

The effects of varying complement coding for the fuzzy ARTMAP neural network were not explored. Reduced classification and learning times might be achieved, but their impact on classification accuracy cannot be predicted.

No attempt was made to study the effects of normality on the classification accuracy of the different algorithms. It would be interesting to study this effect by intentionally skewing the distributions of the training and evaluation data.

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9.0 Appendices

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Source code for the fuzzy K-means AVS module

```
float *dist, int num_clusters, int offset, int skip_zeros);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  int mag_diff(matrix ptr center, matrix ptr old_center, int movement_threshold);
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                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   int build_center_vector(AVSfield_char *input_image, msi_img_ptr input_params,
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                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      /* this will be the output training set */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                      typedef D3_MAT_STRUCT *three_d_matrix_ptr;
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                                                                                                                                                      typedef CLASS_MAP *class_map_ptr;
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                                                                                            CLASS MAP;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               PIX LST;
                                                                                                                                                                                   This software tool creates a fuzzy K means clusters outputs the "classified"
                                                                                                                                                                                                                   image and optionally writes the training data to an output port.
                                                                                                                                                                                                                                                                          Revision history:
12 May 95 now exports training data via the IPIlib
20 May 95 input image sampling by offset implemented
28 June 95 routine can skip zero vectors
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                #include "/cis/src/local/avs/src/IPI/avs_types.h"
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                                                                                         Nessmiller, Steven W.
                                                                                                                      AVS_fuzzy_K_means.c
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#include <IPIllib.h>
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#include <avs/field.h>
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                                                                                            Author:
```

Filename: AVS fuzzy K means.c

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param=AVSadd_parameter("Cluster shift limit:","integer",4,0,INT_UNBOUND
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             param=AVSadd_parameter("Elapsed time (sec):","integer",0,0,INT_UNBOUND)
                                                                                                                                                                                                                                                                                                                                                                                                                    param=AVSadd_float_parameter("Greatest cluster delta:", 0.0, 0.0,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   param=AVSadd_parameter("Generate clusters", "oneshot", 0, 0, 0);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         param=AVSadd_parameter("Skip zero vectors", "boolean", 0, 0, 0);
                                                                                                                                                                                                                                                                                                                                                                      /\star create a widget to display the magnitude of the cluster shift \star/
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                param=AVSadd_parameter("Auto-cluster", "boolean", 0, 0, 0);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            AVSadd_parameter_prop(param, "width", "integer", 4);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      AVSadd_parameter_prop(param, "width", "integer", 4);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             AVSadd_parameter_prop(param, "width", "integer", 4);
                                                                                                                  /\star create a widget to display the limiting cluster shift \star/
AVSadd_parameter_prop(param,"width","integer",2);
                                                                                                                                                                                                                                                AVSadd_parameter_prop(param,"width","integer",2);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     AVSadd_parameter_prop(param,"width","integer",2);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             AVSadd_parameter_prop(param,"width","integer",2);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        AVSfield_float **output_image,
AVSfield **train_out,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            int iteration,
int interface_max_iteration,
int interface_limit,
                                                                                                                                                                                                                                                                                                                                                                                                                                                              FLOAT UNBOUND);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  int compute_fuzzy_K_means(AVSfield_char *input_image,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      int interface_num_clusters,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                float *interface_threshold,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           /* create a widget to skip zero magnitude vectors */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            /\star create a widget to generate the output image \star/
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     AVSset_compute_proc(compute_fuzzy_K_means);
                                                                                                                                                                                                                                                                                          AVSconnect_widget(param,"typein_integer");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           AVSconnect_widget(param, "typein_integer");
                                      AVSconnect_widget(param, "typein_integer");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       /* create a widget to display the elapsed time */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           AVSconnect_widget(param,"typein_real");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      int interface offset,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      AVSconnect_widget(param, "toggle");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                AVSconnect_widget(param, "toggle");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       /* set the function to create the output */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            char *title,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           AVSautofree output (out_port);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      create autogeneration widget */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 /* free the output data */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        MAIN
                                                                                                                                                                                                          ::
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      *
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               ٠.
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           _
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      /* create the output port for the clustered image */ out_port=AVScreate_output_port("Output Image","field 2D uniform float")
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     param=AVSadd_parameter("Number of clusters:","integer",4,1,INT UNBOUND)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           create a widget to display the maximum clustering iteration */
param=AVSadd_parameter("Maximum iteration:","integer",99,0,INT_UNBOUND)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           param=AVSadd_parameter("Iteration number:","integer",0,0,INT_UNBOUND);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    in_port = AVScreate_input_port("Input Image","field 2D uniform byte",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    train_port = AVScreate_output_port("Training Data", Training_Field);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             param=AVSadd_parameter("title","string","Clustering Parameters",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        /* create a widget to set min clustering threshold */
param=AVSadd_float_parameter("membership", 0.9, 0.0, 1.0);
AVSadd_parameter_prop(param,"immediate","boolean",));
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        param=AVSadd_parameter("Sample offset:","integer",1,1,10);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    create a widget to display the clustering iteration number ^{\star}/
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 AVSset_module_name("Fuzzy K Means", MODULE FILTER);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 AVSadd_parameter_prop(param, "width", "integer", 4);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         AVSadd_parameter_prop(param,"width","integer",2);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      AVSadd_parameter_prop(param,"width","integer",2);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     AVSadd_parameter_prop(param,"width","integer",2);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      create a widget to display the image sample size ^{\star}/
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 REQUIRED );
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           create a widget to get the number of clusters ^{\star}/
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      create the input port for the training image */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          /* create the output port for the training data */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               AVSconnect_widget(param, "typein_integer");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        AVSconnect_widget(param,"typein_integer");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               AVSconnect_widget(param, "typein_integer");
                                                                                                                                                    int AVS_fuzzy_K_means();
AVSmodule_from_desc(AVS_fuzzy_K_means);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   int in_port, out_port, train port;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          AVSconnect_widget(param, "dial");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   AVSconnect_widget(param, "text");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               ("","");
                                                                                                                                                                                                                                                                                                                                                                                                                                                   int compute_fuzzy_K_means();
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         train_port = AVScreate_outp
\ \' set the title for the window */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   set the module name and type */
                          /* initialize the modules */
                                                                                                                                                                                                                                                                                                                 /* interface routine */
                                                                                                                                                                                                                                                                                                                                                               AVS_fuzzy_K_means()
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     int param;
                                                             AVSinit_modules()
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               *
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          *
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           *
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    *
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               *
```

```
center->array = matrix(0, center->num_rows-1, 0, center->num_cols-1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       /\star clear out the last elapsed time, iteration, and delta values ^\star/
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             if (old_center == NULL) {
    printf("Unable to malloc old_center matrix pointer\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            membership = (three_d_matrix_ptr)malloc(sizeof(D3_MAT_STRUCT));
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      printf("Unable to malloc membership matrix pointer\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   AVS_VALUE | AVS_MINVAL | AVS_MAXVAL,
                                                                                                                                                                                                                                                                                                                                           printf("Unable to malloc center matrix pointer\n");
                                                                                                               printf("Unable to malloc pixel list pointer.\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     AVS_VALUE | AVS_MINVAL | AVS_MAXVAL,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                AVS_VALUE | AVS_MINVAL | AVS_MAXVAL,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     old_center->num_cols = input_params->num_bands;
old_center->array = matrix(0, old_center->num_rows-1,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             old_center = (matrix_ptr)malloc(sizeof(MAT_STRUCT));
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                AVSmodify float parameter ("Greatest cluster delta:",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        input_params->num_pixels = input_params->num_rows *
                                      pixel list = (pix list ptr)malloc(sizeof(PIX LST));
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           input_params->num_cols;
                                                                                                                                                                                                                                                                     center = (matrix_ptr)malloc(sizeof(MAT_STRUCT));
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             input_params->num_bands = input_image->veclen;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      old_center->num_rows = interface_num_clusters;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       input_params->num_rows = MAXY(input_image);
input_params->num_cols = MAXX(input_image);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       printf("All structures were allocated.\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      center->num_cols = input_params->num_bands;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            0.0, 0.0, 0.0);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                dist = vector(0,interface num clusters-1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       center->num_rows = interface_num_clusters;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  AVSmodify_parameter("Elapsed time (sec):",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          AVSmodify_parameter("Iteration number:",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        /* define the input image parameters */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          /* allocate memory for the arrays */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       0, 0, 0);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           0, 0, 0);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               if (membership == NULL) (
                                                                            if (pixel_list==NULL) {
                                                                                                                                                                                                                                                                                                           if (center -- NULL) {
                                                                                                                                                         return(1);
                                                                                                                                                                                                                                                                                                                                                                                 return(1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             return(1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            return(1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        #ifdef DEBUG
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              #endif
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       AVSmodify_parameter("Generate clusters", AVS_VALUE,0,0,0);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  printf("AVS_fuzzy_K_means just entered the compute function.\n");
printf("Number of clusters = %d.\n", interface_num_clusters);
printf("Membership threshold = %f\n", *interface_threshold);
printf("Maximum iteration = %d.\n", interface_max_iteration);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               printf("Unable to malloc classified image pointer\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    printf("Limiting cluster shift = %d.\n", interface_limit);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              AVSmodify_float_parameter("membership", AVS_VALUE,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       printf("Unable to malloc input image pointer\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         classified = (class_map_ptr)malloc(sizeof(CLASS_MAP));
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             input_params = (msi_img_ptr)malloc(sizeof(MSI_IMG));
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                AVSmark_output_unchanged( "Output Image");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 sendval, 0, 0);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  /* truncate and update the interface */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              temp = *interface_threshold * 100.0;
sendval = ( (int) (temp+0.5) )/100.0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        /* get the threshold value from the dial */
                                                                     int interface_skip_zeros,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           if( AVSparameter_changed("membership") ) {
float *interface_delta,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           /* allocate memory for the structures */
                                                                                                        int auto run,
                                      int time,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                if (input_params == NULL) (
                                                                                                                                              int run)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    register int row, col, cluster;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               float threshold, temp, sendval;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               if (classified == NULL)
                                                                                                                                                                                                                                                                                                                                                                                                                                                   matrix ptr membership;
                                                                                                                                                                                                                                                                                                                                                                                                                    matrix_ptr center, old_center;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          struct timeval before, after;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      int write_training_datafile;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                if (run !! auto run)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                return(1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          return(1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            return(1);
                                                                                                                                                                                                                                                                                                                                       msi_img_ptr input_params;
                                                                                                                                                                                                                                                                                                                                                                                 class_map_ptr classified;
                                                                                                                                                                                                                                                                                                    pix_list_ptr pixel_list;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             int status, converged;
                                                                                                                                                                                                                                                              /* local variables */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   int *indx, *arr;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             else{
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          int dims[2];
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            float *dist;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  #ifdef DEBUG
                                                                                                                                                                                                                                                                                                                                                                                                                                                          three
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              #endif
```

Filename: AVS fuzzy K means.c

```
AVSmessage("beta", AVS_Fatal, NULL, "Fuzzy K means", "Kill module", "Clusters di
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      printf("ERROR: bad status from calc_new_centers.\n");
                                     printf("ERROR: bad status from calc_membership.\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           printf("The fuzzy K-means algorithm converged in %2d iterations\n",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      converged = mag_diff(center, old_center, interface_limit);
                                                                                                                                                                                                                                                                                                                                                                     membership, old_center, center,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        AVS_VALUE | AVS_MINVAL | AVS_MAXVAL,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   printf("Center vectors updated for iteration %d.\n", iteration);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         status = build_output_image(membership, classified, threshold);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       printf("ERROR: bad status from build_output_image.\n");
                                                                                                                                                                                                     printf("Membership calculated for iteration %d.\n", iteration);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    iteration, iteration, iteration);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      if( (!converged) && (iteration > interface_max_iteration) ) {
                                                                                                                                                                                                                                                                                                                            status = calc_new_centers(input_params, input_image,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       /\star allocate then copy the resulting image to output port \star/
                                                                                                                                                                                                                                                                                                                                                                                                          interface_num_clusters,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             AVS VALUE | AVS MINVAL | AVS MAXVAL,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        interface_skip_zeros);
                                                                                                                                                                                                                                                                                                                                                                                                                                                   interface_offset,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                /* check for max iterations and no convergence */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   AVSmodify_parameter("Iteration number:",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           time = (int) (after.tv sec - before.tv sec);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                AVSmodify_parameter("Elapsed time (sec):",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       printf("building the output image...\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        d not converge in maximum allowed iterations.");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      time, time, time);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             threshold = *interface_threshold;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         dims[0] = classified->num_cols;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             /* update interface */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             /* update the elapsed time */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        iteration-1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  /* build the output image */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      gettimeofday(&after, NULL);
                                                                              return(1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               return(1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   /* end of while */
if (status != 1) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 if(status != 1)(
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   iteration +=1;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                return(1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  if(status != 1){
                                                                                                                                                            #ifdef DEBUG
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              #ifdef DEBUG
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 membership
                                                                                                                                                                                                                                              #endif
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        #endif
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          for(cluster = 0; cluster < membership->num_clusters; cluster ++)
                                                                                                                                                            membership->num cols = (int) (input params->num cols/interface offset);
                                                                                                                   membership->num_rows = (int)(input_params->num_rows/interface_offset);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    while ( (!converged) && (iteration <= interface max iteration) ) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  printf("ERROR: bad status from build_center_vector.\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           status = build_center_vector(input_image, input_params, center,
                                                                                                                                                                                                                                                                                                                            0, membership->num_clusters -1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       printf("Fuzzy K means just entered the clustering loop.\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                status = calc_membership(input_params, input_image,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      /* randomly sample the data to get the starting centers */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         membership, center, dist,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               interface_num_clusters,
                                                                                                                                                                                                                                          membership->array = f3tensor(0, membership->num_rows-1,
                                                                                                                                                                                                                                                                                   0, membership->num_cols-1,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        0, classified->num_cols-1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    printf("Initial center vector constructed.\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             interface_skip_zeros);
0, old_center->num_cols-1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             classified->num_rows);
printf("number of columns in the output image = %d.\n",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               classified->array = imatrix(0, classified->num_rows-1,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          printf("Number of columns in the input image = %d.\n",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        for(col = 0; col < membership->num_cols; col ++)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    interface num clusters,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        printf("Number of rows in the output image = %d.\n",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               printf("Number of rows in the input image = %d.\n",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             interface_skip_zeros);
                                                                                                                                                                                                     membership->num_clusters = interface num_clusters;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    interface_offset,
                                                                                                                                                                                                                                                                                                                                                                                                                                               for(row = 0; row < membership->num_rows; row++)
                                                                          /* note the division to support sampling! */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 classified->num_rows = membership->num_rows;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  classified->num_cols = membership->num_cols;
                                                                                                                                                                                                                                                                                                                                                                                                          /* zero out the membership array */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  printf("All arrays allocated.\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  /* iteration control variables */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   input_params->num_cols);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            input_params->num_rows);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           classified->num cols);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         gettimeofday(&before, NULL);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   ->array[row][col][cluster] = 0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               return(1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               if(status == 1)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           converged = 0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                iteration = 0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                else{
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             #ifdef DEBUG
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  #ifdef DEBUG
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    #endif
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                #endif
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A-5

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0, membership->num_clusters -1);
                                                                                                                                                                                                                                                                                                                   free_f3tensor(membership->array, 0, membership->num_rows-1,
                                      0, membership->num cols-1,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   takes num_cluster random points from the data matrix and
                                                                                                                                            free_ivector(indx, 1, pixel_list->num_pixels);
                                                                                                                                                                                                                free_ivector(arr, 1, pixel_list->num_pixels);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          /* return success */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                function build_center_vector
                                                                                                                                                                                                                                                                                                                                                                                                                                                                free (input_params);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                free (classified);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                /* end of main */
                                                                                                                                                                                                                                                                                                                                                                                                                             free (old_center);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   free (membership);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      free (pixel_list);
                                                                                                                                                                                                                                                                                                                                                                                             free (center);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          return (1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             classified->array[row][col];
                                                                                                                                                                                                                                                                                                                ( AVSdata_alloc( "field 2D uniform scalar float", dims ));
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             ( AVSdata_alloc( "field 2D uniform scalar float", dims ));
                                                                                                      printf("Allocating the %d rows by %d columns output image.\n",
                                                                                                                                                                                                                                                                                                                                                                                                                      ( dims[ 1 ] != MAXY( *output_image ) ) ) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          for(col =0; col < classified->num_cols; col++)
                                                                                                                                                                                                                                                                                                                                                                                   else if ( ( dims[ 0 ] != MAXX( *output_image ) ) ||
                                                                                                                                                                                                                                                                                                                                                                                                                                                         AVSfield_free( (AVSfield *) *output_image );
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          I2D(*output_image, col, row) =
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      for(row=0; row < classified->num_rows; row++)
                                                                                                                                                                                                                                                                                *output_image = ( AVSfield_float * )
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         *output_image = ( AVSfield_float * )
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   printf("Output field allocated.\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                printf("Output field written.\n");
dims[1] = classified->num_rows;
                                                                                                                                                                                                                                                if ( *output_image == NULL ) {
                                                                                                                                         dims[0], dims[1]);
                                                                      #ifdef DEBUG
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             #1fdef DEBUG
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                #endif
                                                                                                                                                                            #endif
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(float)( *(I2DV(input_image,index2,index1)+band));
                                                                     int build_center_vector(AVSfield_char *input_image, msi_img_ptr input_params,
                                                                                                                 matrix_ptr center, int num_clusters, int zero_flag)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                for (band = 0; band < input_params->num_bands; band++) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              index1 = (int) ( (input_params->num_rows * x) + 0.5 );
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           index2 = (int)( (input_params->num_cols * y) + 0.5 );
utilizes them as the initial centers of the data clusters
                                                                                                                                                                                                                                                                                                                                                                                                                                                                            printf("\nBuilding the random center vector.\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        center->array[row][band]
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     for (row=0; row < num_clusters; row++) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 /* initialize the random number generator */
                                                                                                                                                                                                                                                                          int index1, index2, status, magnitude;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              x = ranl(&idum);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          y = ranl(&idum);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               magnitude =0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            x = ranl(&idum);
                                                                                                                                                                                                                                      register int row, band;
                                                                                                                                                                                                                                                                                                                                                       long idum = (-13);
                                                                                                                                                                                                                                                                                                                                                                                                                                       #ifdef DEBUG
                                                                                                                                                                                                                                                                                                               float x, y;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    #endif
```

0, classified->num_cols-1);

free_imatrix(classified->array, 0, classified->num_rows-1,

0, old center->num cols-1);

free_matrix(old_center->array, 0, old_center->num_rows-1,

0, center->num_cols-1);

free_matrix(center->array, 0, center->num_rows-1,

free_vector(dist, 0, interface_num_clusters-1);

/* free all the allocated memory */

magnitude += center->array[row][band];

if (zero flag -- 1)

1, pixel_list->num_bands+1);

pixel_list->array =imatrix(1, pixel_list->num_pixels,

pixel_list->num_pixels = classified->num_valid_pixels;
 pixel_list->num_bands = input_params->num_bands;

pixel_list->num_classes = interface_num_clusters;

/* allocate then build the training set */

status = build_training_set(input_image, input_params, pixel_list,

indx = ivector(1, pixel_list->num_pixels);
arr = ivector(1, pixel_list->num_pixels);

classified, indx, arr, train_out,

interface_offset);

printf("ERROR: bad status from build_training_set.\n");

return(1);

if(status != 1){

```
image_col, image_row) +band));
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        for(cluster = 0;cluster < membership->num_clusters; cluster++) {
    dist[cluster] = distance(image_row, image_col, cluster,
        input_image, input_params, center);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             for (band = 0; band < input_params->num_bands; band ++)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              /st not near any cluster center, so calculate its membership to all cluster st/
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              /* point is very near a cluster center. Set its membership to that cluster
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             for (cluster =0; cluster < num_clusters; cluster++)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            membership->array[row][col][cluster]=0.0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         magnitude +=(int)( *(I2DV(input_image,
                                                                                                                                                                                                                                         int index, flag, status, image_row, image_col, magnitude, zero_flag;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           /\star calculate the distance from the point to each cluster center \star/
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               membership->array[row][col][index] = 1.0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           for (col = 0; col < membership->num_cols; col++) (
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          zero_flag = 1;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              if (magnitude == 0)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         if (dist[cluster] < small) {</pre>
                                                                                                                                                                                                                                                                                                                                                                                                                                           for (row = 0; row < membership->num_rows; row++) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           index = col;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         /* see if we have a zero magnitude pixel */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             flag = 1;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       image_col = offset * col;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          magnitude = 0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            if (skip_zeros == 1) (
                                                                                                                                                                                                           register int row, col, band, cluster;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               temp = 0.0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                             image_row = offset * row;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                flag = 0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               to one and zero all others */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              zero flag = 0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            if (flag==1) (
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         if(zero_flag != 1) {
                                                                                                                                                                                                                                                                           float temp, factor, small;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 else{
                                                                                                                                                                                                                                                                                                                                                                            small = 1.0;
                                                                                                                                                                                                                                                                                                                                             flag = 0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     determines the distance between a data point and the different cluster
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      value = (float)( *(I2DV(input_image,col,row)+band));
temp = pow( (value - center->array(cluster_num][band]), 2.0);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   float distance(int row, int col, int cluster_num, AVSfield_char *input_image,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        printf("%3f\t", center->array[row][band]);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       for (band = 0; band < center->num_cols; band++) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        for (band = 0; band < input_params->num_bands; band++) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       msi_img_ptr input_params, matrix_ptr center) {
                                                                     if( (magnitude == 0) && (zero_flag == 1) ){
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     printf("Random center[%2d] = ", row);
                                                                                                                                                                                                                                                                                                                                                                                                                                  printf("The random center vector is :\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                 for (row=0; row < num_clusters; row++) {
/* end band loop */
                                                                                                                                                                         row = 0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     /* end of build_center_vector */
                                                                                                                                     if (row == -1)
                                                                                                       row -= 1;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     float dist, temp, output, value;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     printf("\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        /* end of distance */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         dist += temp;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          output = sqrt(dist);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         Function calc_membership
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         return (output);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         return(status);
                                                                                                                                                                                                                                                                                                                                                                                                    #ifdef RANDOM DEBUG
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       status = 1;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        dist = 0.0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       register int band;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      function distance
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         centers
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       #endif
```

Calculates the membership value for each of the data points with

respect to each cluster center.

for (cluster =0; cluster < num_clusters; cluster++)
 temp+=1.0/(dist[cluster]*dist[cluster]);</pre>

```
(1.0/(dist[cluster]*dist[cluster]))/(factor);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   old_center->array[row][band] = center->array[row][band];
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     for (cluster = 0;cluster < membership->num_clusters;cluster++)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     printf("%3f\t", membership->array[row][col][cluster]);
                                                                        for(cluster = 0; cluster < num_clusters; cluster++)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              calculate the new centers of the clusters based on the results from
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          int calc_new_centers(msi_img_ptr input_params, AVSfield_char *input_image,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  three_d_matrix_ptr membership, matrix_ptr old_center,
                                                                                                                    membership->array[row][col][cluster] =
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           register int band, cluster, row, col;
int status, num_features, image_row, image_col, magnitude, zero_flag;
float denom, image_value, *numex;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      matrix_ptr center,int num_clusters, int offset,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             printf("membership[%2d][%2d] = ", row, col);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               /* transfer the cluster centers from center to old_center */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         for (col = 0; col < membership->num_cols; col++) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           for (band=0; band < num features; band++)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 for (row = 0; row < membership->num_rows; row++) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           num_features = input_params->num_bands;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       for (row=0; row < num_clusters; row++)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   numer = vector(0, num_features-1);
factor = temp;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                         /* end of col loop */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              int skip_zeros)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          the membership function
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              ) /* end of calc_membership */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             /* end of row loop */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  printf("\n");
                                                                                                                                                                                                                                                                                                                /* end if */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          function calc new centers
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         #ifdef MEMBERSHIP DEBUG
                                                                                                                                                                                                                                                                                                                                                                                         zero_flag = 0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  return(status);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              8-A status = 1;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 #endif
```

```
for (band = 0: band < input_params->num_bands: band++) {
  image_value =  *(I2DV(input_image, image_col, image_row)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     membership->array[row][col][cluster],2.0) * image_value;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   denom += pow( (double)membership->array(row][col][cluster],2.0)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     magnitude += *(I2DV(input_image, image_col, image_row) + band);
                                                                                                                                                                                                                                                                                                                                                                                  image_row = offset * row;
for (col = 0; col < membership->num_cols; col++){
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     center->array[cluster][band] = numer[band]/denom;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          for (band = 0; band < input_params->num_bands; band++) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 for (band = 0; band < input_params->num_bands; band++)
                                                                                                                                                                                       for (band = 0; band < input_params->num_bands; band++)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                printf("%3f\t", center->array[row][band]);
                                                                                                                                                                                                                                                                                                                                               for (row = 0; row < membership->num_rows; row++)(
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              for(band = 0; band < input params->num bands; band++)
                                                                                                                                                                                                                                                                                                        /\star calculate the denominator term and numerator terms \star/
                                   for (cluster = 0; cluster < num_clusters; cluster++)(</pre>
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 numer[band] += pow( (double)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  /* end band loop */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              + band);
                                                                                                                                                                                                                                                                                                                                                                                                                                                     image_col = offset * col;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      printf("New center[%2d] = ", row);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   for (row=0; row < num_clusters; row++) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   /* end col loop */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                /* end row loop */
                                                                                                             /* initialize summing variables */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               /* end of cluster loop */
                                                                                                                                                                                                                                 numer[band]=0.0;
/* Calculate the new centers */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              /* calculate the new center */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      /* check for zero vectors */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                if (zero_flag != 1) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                /* end if */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           if (magnitude == 0)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               zero_flag = 1;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       if (skip_zeros == 1) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           printf("\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            #ifdef CENTER_DEBUG
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                zero_flag = 0;
```

```
int build_output_image(three_d_matrix_ptr membership, class_map_ptr classified,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    /* end of row loop */
                                                                                                                                                                                                                                                                                                                                                                                                                                                           max = -1.0;
                                                                                                                      register int row, col, cluster;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 printf("\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          else
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            return(status);
                                                                                                                                                  int max index, status;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                status = 1;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               #ifdef CLASS_DEBUG
                                                                                                                                                                               float value, max;
                                                                                                                                                                                                                                  #ifdef DEBUG
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          #ifdef DEBUG
                                                                                                                                                                                                                                                                                                                     #endif
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         #endif
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       #endif
                                                                                                                                                                                                                                                                                                                                                                                                                    int mag_diff(matrix_ptr center, matrix_ptr old_center, int movement_threshold)
                                                                                                                                                                                                                                                                                                          calculates the difference between old_center and center to determine
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        this function creates the output image from the input image and the membership matrix with reguard to the user selected threshold value.
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        AVSmodify_float_parameter("Greatest cluster delta:",
AVS_VALUE | AVS_MINVAL | AVS_MAXVAL,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     old_center->array[row][col];
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         temp = center->array[row][col] -
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            for (col=0; col < num features; col++) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      max, max, max);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          difference += fabs(temp);
                                                      free_vector(numer, 0, input_params->num_bands-1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    for (row=0; row < num_clusters; row++) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  /* end of col loop */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  max = difference;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     num_clusters = center->num_rows;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 num_features = center->num_cols;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      register int row, col;
int result, num_clusters, num_features;
float temp, difference, max;
                                                                                                                                                                                                                                                                                                                                    if the clusters have converged.
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      if (difference > max) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          if ( max > movement_threshold)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     /* end of row loop */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                difference = 0.0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      function build_output_image
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            result = 1;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      result = 0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              max = -1.0;
                                                                                                                                                                                                                                                                                 function mag_diff
                                                                                                                                        return(status);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  return(result);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                else
                                                                                                            status = 1;
#endif
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     A-9
```

```
printf("Of %d total pixels, %d fall within the threshold criteria.\n",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           value = membership->array[row][col][cluster];
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               for(cluster = 0; cluster < membership->num_clusters;
                                                                                                                                                                                                                                                                                                                                                                                      classified->num valid pixels = 0;
/* scan the membership matrix for the maximum cluster membership value */
for(row = 0; row < classified->num_rows; row+) {
   for(col = 0; col < classified->num_cols; col++) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                classified->array[row][col] = max_index;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       classified->num_rows * classified->num_cols,
                                                                                                                                                                                                                                                                         printf("Building the %d rows by %d columns output image.\n",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            printf("%d\t", classified->array[row][col]);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         classified->num_valid_pixels += 1;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    for (col = 0; col < classified->num_cols; col++) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   max_index = cluster + 1;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      classified->array[row][col] = 0;
                                                                                                                                                                                                                                                                                                              classified->num_rows, classified->num_cols);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            /* end of cluster loop */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        classified->num valid pixels);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                for (row=0; row < classified->num_rows; row++) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               max = value;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    printf("This is the classified image:\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   if (value > max) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        if (max >= threshold) (
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      /* end of col loop */
float threshold) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       cluster++) (
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      /* end of build_output_image */
```

int

Last Updated: Thu Aug 31 01:16:37 1995

```
printf("This is the sorted pixel list:\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    set_row += 1;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               #ifdef TRAINING SET DEBUG
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            start_row = 1;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           set row =0;
                                                                                                                                                                                                                                                                                                                                                                                                               #endif
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           #endif
                                                                                                                                                                                                                                                                                                                             int *indx, int*arr, AVSfield **trainfield, int offset) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  classified->array[row][col];
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            (I2DV(input_image,image_col,image_row)+band);
                                                                              this function creates the training set from the output image and the
                                                                                                                                                                                                                                           int build_training_set(AVSfield_char *input_image, msi_img_ptr input_params,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              for(band=0; band < input_params->num_bands; band++){
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         pixel_list->array(list_row)(input_params->num_bands + 1) =
                                                                                                                                                                                                                                                                                    pix_list_ptr pixel_list, class_map_ptr classified,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      /* calculate total pixels and # in each class */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       pixel list->array[list row][band+1] =
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    length[ classified->array[row][col] ] += 1;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        for (class = 1; class <= pixel_list->num_classes; class++)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              image_row = offset * row;
for(col = 0; col < classified->num_cols; col++) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                 int status, list_row, start_row, set_row, image_col;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          /\star scan the classified matrix for values other than zero \star/
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              /* the pixel_list array is ONE based to support the sort */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        for(row=0; row < classified->num_rows; row++) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               vector = dvector(0, input_params->num_bands-1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               length = ivector(1, pixel_list->num_classes);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             if(classified->array[row][col] > 0) (
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    image_col = offset * col;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     /* allocate and initialize the length vector */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          } /* end band */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               list row += 1;
                                                                                                                                                                                                                                                                                                                                                                                                            register int row, col, band, class;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 length[class] = 0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              IPItraining trainchain - NULL;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       IPItraining trainset - NULL;
                                     function build training set
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            total_training_points;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       list_row = 0;
                                                                                                                           input image.
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        double *vector;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              *length;
```

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```
vector[band] = (double)pixel_list->array[indx[row]][band+1];
                                                                                            printf("%d\t", pixel_list->array[indx[row]][band]);
for (row = 1; row <= pixel_list->num_pixels; row++) {
   for (band = 1; band <= pixel_list->num_bands+1; band++) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          printf("Sending class %d's %d pixels to the training set.\n", class, length[class]);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      for (row = start_row; row < start_row+length[class]; row++)(</pre>
                                                                                                                                                                                                                                                                                                                                                                     printf("Length of class[%d] = %d\n", class, length[class]);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  IPIset_training_bands(trainset, input_params->num_bands);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    IPItraining to field (trainchain, trainfield, NULL, 0); printf("Total of %d pixels were written to the training set.\n",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   for (band = 0; band < pixel_list->num_bands; band++) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       IPlappend to training_chain(*trainchain, &trainset);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            IPIset_training_vector(trainset, set_row, vector);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          for (class = 1; class <= pixel_list->num_classes; class++) {
   /* initialize the trainset */
                                                                                                                                                                                                                                                                                                                               for (class = 1; class <= pixel_list->num_classes; class++)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            IPIset_training_length(trainset, length[class]);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      printf("length of training set = %d.\n", length[class]);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 IPIset_training_gis(trainset, class):
IPIset_training_datatype(trainset, IPI_byte);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               total_training_points += length[class];
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         printf("Number of training bands set to %d.\n",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       printf("Set %d appended to chain. \n", class);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              /* write the results to the output port */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       input_params->num_bands);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     printf("GIS value set to %d.\n", class);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               printf("Data type set to byte.\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 start_row += length[class];
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                } /* end band loop */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     total_training_points);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         } /* end row loop */
                                                                                                                                                                                                                                   printf("\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                total_training_points = 0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  } /* end class loop */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  set_row = 0;
```

iindexx(classified->num_valid_pixels,arr,indx);

#ifdef TRAINING SET DEBUG

/* sort the arr vector */

} /* end row */

} /* end col */

} /* end if

arr[list_row] = classified->array[row][col];

Filesize: 36.04 kbytes

Filename: AVS fuzzy K means.c

Source code for the Class Statistics and GML Classification AVS modules

Summary: Author:

```
#include "/cis/src/local/avs/src/IPI/avs_types.h"
                                                                                                                                                                                                                                                                                                                                                                                                         /* layered debug definitions */
                                                                                                                                                                                                                                              #include <avs/avs_data.h>
#include <IPIllib.h>
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              int num_classes;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                int num_pixels;
                                                                                                                                                                                                    #include <avs/field.h>
                                                                                                                                                           #include <sys/types.h>
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       int num bands;
                                                                                                                                                                                                                         #include <avs/flow.h>
                                                                                                               #include <sys/time.h>
                                                                                                                                    #include <sys/file.h>
                                                                                                                                                                                                                                                                                                                                                            #include "lu_dcomp.h"
                                                                                                                                                                                #include <avs/avs.h>
                                                                                                                                                                                                                                                                                                              #include "memutil.h"
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            int **array;
                      #include <stdlib.h>
                                                                  #include <string.h>
                                             #include <stddef.h>
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     #define PIXEL_DEBUG
#include <stdio.h>
                                                                                                                                                                                                                                                                                                                                                                                                                                                     #define MEAN_DEBUG
                                                                                         #include <math,h>
                                                                                                                                                                                                                                                                                                                                     #include "imat.h"
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   #define INV_DEBUG
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            #define DET_DEBUG
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       #define MAXSTR 80
                                                                                                                                                                                                                                                                                                                                                                                                                                                                         #define VC_DEBUG
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              #define LU_DEBUG
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     typedef struct{
                                                                                                                                                                                                                                                                                                                                                                                                                                #define DEBUG
```

```
int write_output(char *filename, matrix ptr mean, three_d_matrix_ptr inv_vc, three_d_matrix_ptr vc, float *log_det, float *determinant);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  in_port = AVScreate_input_port("Input Training Set", Training_Field,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         param=AVSadd_parameter("Number of training sets:", "integer", 0, 0,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               param=AVSadd_parameter("Statistics file (*.sta):","string",cwd, 0,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     param = AVSadd_parameter("View all file types", "boolean",0,0,1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 "Training class statistics", "", "");
int calc_mean_vectors(pix_list_ptr pixel_list, matrix_ptr mean);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           AVSset_module_name("Class Statistics", MODULE_FILTER);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     /* create a widget to display the number of training sets */
                                       AVSadd_parameter_prop(param, "width", "integer",4);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   AVSadd_parameter_prop(param, "width","integer",4);
AVSconnect_widget(param, "browser");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        AVSadd parameter prop(param, "width", "integer", 4);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        /\star create a widget for the output statistics filename \star/
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      REQUIRED );
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          \prime^{\star} create the input port for the training data ^{\star}\prime
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      param=AVSadd_parameter("title","string",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    INT UNBOUND);
                                                                                                                                                                                                                                                                                                                                                                                         AVSmodule_from_desc(AVS_classtat);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            AVSconnect_widget(param, "text");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              /* allow user to view all file types */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              ".sta");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       if ( cvd[strlen(cwd)-1] != '/')
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     /* set the title for the window */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              /* set the module name and type */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           strcat(cwd,"/");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   int compute_classtat();
                                                                                                                                                                                                                                                                                                                                                     int AVS_classtat();
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   char cwd[MAXSTR];
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             /* interface routine */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           int in_port;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   getwd(cwd);
                                                                                                                                                                                                                                                                          AVSinit_modules ()
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       int param;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        AVS_classtat()
```

Filename: AVS classtat.c

typedef PIX_LIST *pix_list_ptr;

PIX LIST;

float ***array;

typedef struct{

param=AVSadd_parameter("Number of training pixels:", "integer", 0, 0,

INT UNBOUND);

AVSadd_parameter_prop(param,"width","integer",2);

AVSconnect_widget(param, "typein_integer");

/* create a widget to display the number of training pixels */

AVSadd_parameter_prop(param,"width","integer",2);

AVSconnect_widget(param, "typein_integer");

 $/\star$ create a widget to display the number of bands in the training sets $\star/$ param=AVSadd_parameter("Number of bands:", "integer", 0, 0,

AVSadd_parameter_prop(param,"width","integer",2);

INT UNBOUND);

AVSconnect_widget(param,"typein_integer");

```
register int class_index, row, col, i, i2, j, band, class;
                                                                                                                                                                                                                                                                                                                                                                                          static char old_stats_filename[80];
                                                                                                                                                                                                                                                                                                                                                                                                                       char *reset_stats_filename = " ";
                                                                                                                                                                                                                                                            IPItraining trainchain = NULL;
                                                                                                                              int status, n, elapsed_time;
struct timeval before, after;
                                                                                                                                                                                                                                                                                            IPItraining trainset = NULL;
                                                                                                                                                                                                                                                                                                                                                          static int file_status = 0;
int training_bands, flag;
                                                                                                                                                                                                                                                                                                                            static int new_file = 0;
                                                                                                                                                                                              double *train vector;
                                                             FILE *output file;
                                   char *answer;
                                                                                                                                                                                                                              int list row;
```

```
AVSmodify_parameter("Statistics file (*.sta):",
                                                                                                                                                                                                                                              AVSmodify_parameter("Statistics file (*.sta):",
                                                                                                                                                            AVS_VALUE|AVS_MAXVAL, "/tmp/",0,""); printf( "Setting maxval to null\n");
                                                                                                                                                                                                                                                                                   AVS_VALUE, stats_filename, 0, 0);
                                        if(AVSparameter_changed("View all file types")){
/* check for view all parameter filenames */
                                                                                     if (all) (
```

```
AVS_VALUE, stats_filename, 0, 0);
                                            AVSmodify_parameter("Statistics file (*.sta):",
                                                                                         AVS VALUE AVS MAXVAL, "/tmp/", 0, ".sta");
                                                                                                                                                                           AVSmodify_parameter("Statistics file (*.sta):",
                                                                                                                                  printf( "Setting maxval to .sta\n");
else{
```

param=AVSadd_parameter("Generate statistics file","oneshot", 0, 0, 0);

create a widget to generate the statistics file $^{\star}/$

AVSadd_parameter_prop(param, "width", "integer", 4);

AVSset_compute_proc(compute_classtat);

 $/\star$ set the function to create the output $\star/$

param=AVSadd_parameter("Auto-generate statistics file","boolean",0,

AVSadd_parameter_prop(param, "width", "integer", 4);

0,0

AVSconnect_widget(param, "toggle");

param=AVSadd_parameter("Elapsed time (sec):", "integer",0,

0, INT UNBOUND);

/* create a widget to display the elapsed time */

AVSadd_parameter_prop(param,"width","integer",2);

AVSconnect_widget(param,"typein_integer");

/* create autogeneration widget */

```
new file = 0;
```

```
if(stats_filename[strlen(stats_filename) - 1] == '/'){
/* make sure we've got a file NOT just a directory */
                                                                                                                        return(1);
```

```
status = strcmp(stats_filename, old_stats_filename);
/* see if the statistics filename has changed */
```

```
strcpy(old stats filename, stats filename);
                                                                                         output_file = fopen(stats_filename, "r+");
if (status != 0) {
```

interface_num_classes,

char *stats_filename,

int all, int int int

char *title,

int compute_classtat(AVSfield *input,

main compute function

interface_num_pixels,

interface num bands,

int auto_run, int run)

int time,

```
printf("Class statistics file does not exist.\n");
                             new_file = 1;
                                                                         else{
```

if(output_file == NULL)(

```
/* file already exists, close and check for overwrite */
                                           fclose (output_file);
```

```
printf("Statistics file already exists.\n");
if (file status == 0){
```

Filename: AVS classtat.c

three_d_matrix_ptr vc, lu_vc, inv_vc;

float *determinant; float *col_vector;

float d;

float *log_det;

pix_list_ptr pixel_list; /* local variables */

matrix_ptr mean;

```
printf("Unable to malloc the LV decomposed matrix pointer.\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              /\star get number of bands in the training sets and update the interface \star/
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                pixel_list->num_classes = IPIlength_of_training_chain( trainchain );
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   printf("There are %d classes of data.\n", pixel_list->num_classes);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           /\star get the number of training classes and update the interface \star/
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              printf("Unable to malloc the inverse matrix pointer.\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   AVS_VALUE | AVS_MINVAL | AVS_MAXVAL,
interface_num_classes, interface_num_classes,
interface_num_classes);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    interface_num_bands, interface_num_bands,
                                                                                                       printf("Unable to malloc the vc matrix pointer.\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              printf("All the structures were successfully allocated.\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           inv_vc = (three_d_matrix_ptr)malloc(sizeof(D3_MAT_STRUCT));
                                                                                                                                                                                                                                               lu_vc = (three_d_matrix_ptr)malloc(sizeof(D3_MAT_STRUCT));
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              AVSmodify_parameter("Number of bands:",
AVS_WAXVAL,
                                 vc = (three_d_matrix_ptr)malloc(sizeof(D3_MAT_STRUCT));
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              printf("There are %d bands in the training sets.\n",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      IPIget training bands (trainchain, &training bands);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    interface_num_classes = pixel_list->num_classes;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      IPIfield_to_training(input,NULL,&trainchain,0);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     AVSmodify_parameter("Number of training sets:",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             interface_num_bands = pixel_list->num_bands;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         interface num bands);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       pixel_list->num_bands = training_bands;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 printf("Training field converted.\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     /* Convert the training field */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      pixel_list->num_bands);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         return(1);
                                                                                                                                                  return(1);
                                                                                                                                                                                                                                                                                                                                                                                                 return(1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         if (inv_vc==NULL) (
                                                                                                                                                                                                                                                                                if (lu_vc==NULL)
                                                                  if (vc==NULL)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      #ifdef DEBUG
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             #ifdef DEBUG
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   #ifdef DEBUG
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   #ifdef DEBUG
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        #endif
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   #endif
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         #endif
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          #endif
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               if( (run || auto_run) && (file_status || new_file) )
AVSmodify_parameter("Generate statistics file",AVS_VALUE,0,0,
                                                                     "Class statistics file %s already exists.\n",
answer = AVSmessage("beta",AVS_Warning,NULL,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    printf("Class statistics just entered the compute function.\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              printf("The output filename is: %s\n", stats filename);
                                 "Class Statistics","Overwrite!Cancel",
                                                                                                                                                                                if( strcmp(answer,"Overwrite") == 0 )
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 printf("Unable to malloc pixel list pointer.\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           AVS_VALUE | AVS_MINVAL | AVS_MAXVAL, 0,0,0);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                AVS_VALUE | AVS_MINVAL | AVS_MAXVAL,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   AVS_VALUE | AVS_MINVAL | AVS_MAXVAL,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      AVS VALUE | AVS MINVAL | AVS MAXVAL,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              pixel_list = (pix_list_ptr)malloc(sizeof(PIX_LIST));
if (pixel_list==NULL) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       strcpy(old_stats_filename, reset_stats_filename);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       AVSmodify_parameter("Number of training pixels:",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              AVSmodify_parameter("Number of training sets:",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             if ( (file_status == 1) || (new_file ==1) )
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 AVSmodify_parameter("Elapsed time (sec):",
                                                                                                          stats_filename);
                                                                                                                                                                                                                    file_status = 1;
                                                                                                                                                                                                                                                                                       file_status = 0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             /\star allocate memory for the structures \star/
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      AVSmodify parameter ("Number of bands:",
                                                                                                                                                                                                                                                                                                                           return(1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             /* reset the static variables */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    0,0,0,0
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          0,0,0
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           :(0,0,0
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          /* reset the display */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       return(1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              return(1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         return(1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      file_status = 0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 /* check if run time */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     new file = 0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      else
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                else
```

A-15

Filename: AVS classtat.c

```
IPIget_training_vector(trainset, row - list_row, train_vector);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       for(class index=1; class index <= lu_vc->num_classes; class_index++)
                                                                                                                                                                                                                                                                                                                                                                                                                               pixel_list->array[row][band] = (int)train_vector[band];
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            /\star ludcmp expects a 1 based array just to make life interesting \star/
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              printf("The variance covariance matrix has been calculated.\n");
                                                                                                                                                                                                                                                           for(row = list_row; row < list_row + length[class]; row++) {</pre>
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         pixel list->array[row][pixel_list->num_bands] = class;
                                                                                                                                                                                                                                                                                                                                                                                    for(band = 0; band < pixel_list->num_bands; band++) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           /\star first allocate storage for the LU decomposed matrices \star/
                                                                                      for(class = 0; class < pixel list->num classes; class++) {
                                                                                                                             IPInext_on_training_chain( &trainchain, &trainset );
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   for(band = 0; band <= pixel_list->num_bands; band++) {
   printf("%d\t", pixel_list->array[row][band]);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            printf("Class %d successfully read in.\n", class);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         free_dvector(train_vector,0,pixel_list->num_bands-1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         printf("The mean vectors have been calculated.\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            /* print out the training pixels */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  for(row=1; row <= lu_vc->num_rows; row++)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           /* Calculate the variance-covariance matrices */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           /* read the vc matrices into the lu vc arrays */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        printf("Training data successfully read in.\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        lu_vc->array = f3tensor(1, lu_vc->num_classes,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  status = calc mean vectors(pixel list, mean);
                                                                                                                                                                    printf("Reading in class %d.\n", class);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       status = calc_vc_matrix(pixel_list, mean, vc):
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  1, lu_vc->num_cols);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       1, lu vc->num rows,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         lu_vc->num_classes = vc->num_classes;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    /* Accomplish the LU decomposition */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                lu_vc->num_bands = vc->num_bands;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           /* Calculate the mean vectors */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       lu_vc->num_rows = vc->num_rows;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  lu_vc->num_cols = vc->num_cols;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    list_row += length[class];
                                                                                                                                                                                                                                                                                                                                                                                                                                                                           } /* end band loop */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  } /* end of row loop */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       qettimeofday(&before, NULL);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              } /* end of class loop */
                                           trainset = NULL;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    printf("\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               #ifdef PIXEL DEBUG
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        #ifdef DEBUG
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               #endif
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       #endif
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         "Not enough pixels in the training classes. The var
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              AVSmessage ("beta", AVS_Error, NULL, "Class Statistics", "Okay",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    printf("Total number of pixels = %d.\n", pixel_list->num_pixels);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               interface num pixels, interface num pixels,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      printf("Number of pixels per class has been calculated.\n");
                                                                                                                                                                                                                                                                                                                                         /* get the pixel list parameters and allocate memory */
length[ class ] = IPIsize_of_training_set(trainset);
pixel_list->num_pixels += length[ class ];
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        for(class = 0; class < pixel_list->num_classes; class++) {
    printf("The number of pixels in class %d is %d.\n",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       for(class = 0; class < pixel_list->num_classes; class++) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          IPInext_on_training_chain( &trainchain, &trainset ); printf("Executed next_on_training_chain again.\n");
                                                                                                                                                                                                               printf("Just executed first next_on_training_chain.\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               pixel_list->array = imatrix(0, pixel_list->num_pixels-1,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   AVS VALUE | AVS MINVAL | AVS MAXVAL,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                printf("Could not allocate the pixel list.\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  0, pixel_list->num_bands);
                                                                                                                                                                    IPInext_on_training_chain( &trainchain, &trainset );
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    /* check to ensure enough pixels in each class! */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               /* read the training data into the pixel_list structure */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  train_vector = dvector(0,pixel_list->num_bands-1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              if(length[class] < pixel_list->num_bands)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        AVSmodify_parameter("Number of training pixels:",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         interface_num_pixels = pixel_list->num_pixels;
                                                                                      length = ivector(0, pixel_list->num_classes);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                iance covariance matrix will not be invertible. \n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      interface_num_pixels);
/* Get all the training set information */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         printf("Pixel list allocated.\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  class, length[class]);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         if(pixel list->array == NULL) {
                                                                                                                                                                                                                                                                                                      while (trainset != NULL) (
                                           pixel list->num pixels = 0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               return(1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               return(1);
                                                                                                                                 trainset = NULL;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       if (flag == 1) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       list row = 0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               flag = 0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              else
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         #ifdef DEBUG
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    #endif
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              A-16
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Filesize: 32.33 kbytes

Filename: AVS classtat.c

```
col_vector[i2];
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            printf("%f ",inv_vc->array[class_index][row][col]);
                                                                                                                                                                                                                                                                         for (class_index = 1;class_index<=inv_vc->num_classes;class_index++) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           for(class_index=1;class_index<=inv_vc->num_classes;class_index ++)(
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           /\star debug code - print out the inverted matrices \star/
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           inv_vc->array[class_index][i2][j]=
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           for(col=1; col <= inv_vc->num_cols; col++)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                      lubksb(lu_vc->array[class_index], n,
index[class_index], col_vector);
for(i2=1; i2 <= n; i2++)</pre>
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       for(row=1; row <= inv_vc->num_rows; row++) {
Last Updated: Thu Aug 31 01:16:32 1995
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       printf("\nThese are the inverted matrices:\n\n");
                                                                                                                                                        1, inv_vc->num_cols);
                                                                                                                                                                                                                                                                                                                                                                                             col_vector[i]=0.0;
                                                                                                                                                                                                                                                                                                                                                         for(i=1; i <= n; i++)
                                                                                                                                                                                                                                                                                                                                                                                                                                     col_vector[j] = 1.0;
                                                                                                                                                                                                                                                                                                             for (j=1; j <=n; j++) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         printf("\n");
                                                                                                                                                                                                                                     col_vector=vector(1,n);
                                                                                                                                                                                                n = inv_vc->num_bands;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               #ifdef INV DEBUG
                                                                                                                                                                                                                                 vc->array[class_index-1][row-1][col-1];
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           for(class_index = 1; class_index <= lu_vc->num_classes; class_index++) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         printf("\nThese are the values of the elements in the lu_vc matrix\n\n")
Printed: Thu Sep 7 08:58:11 1995
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           /\star debug code - print out the lu decomposed matrices and the index matrix \star/
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           ludcmp(lu_vc->array[class_index], n, index[class_index],&d);
                                                                                                                                                                                         lu_vc->array[class_index][row][col] =
                                                                                                                                                 for (col=1; col <= vc->num_bands; col++)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   printf("\nThese are the values in the index matrix\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        printf("%d ",index[row][col]);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           for(row=1; row <= lu_vc->num_classes; row ++) {
                                                                                                                                                                                                                                                                                                                                                                                          index = imatrix(1,lu_vc->num_classes,1,n);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                for (col = 1; col <= n; col++)
                                                                                                                                                                                                                                                                                                             /* send each lu_vc array to ludcmp */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   determinant[class_index]=d;
                                                                                                                                                                                                                                                                                                                                                                                                                              determinant = vector(1,n);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                      log_det = vector(l,n);
                                                                                                                                                                                                                                                                                                                                                     n = lu_vc->num_bands;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            printf("\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       #lfdef LU DEBUG
```

```
determinant[class index] *= lu_vc->array[class_index][row];
log_det[class_index] = (float) log((double)determinant[class_index]);
                                               /\star calculate and store the determinant of each LU decomposed matrix \star/
                                                                                           for(class_index=1; class_index <= lu_vc->num_classes; class_index++) (
                                                                                                                                                                                                                                                                                                                                                                                                                                                                         for(class_index=1; class_index <= lu_vc->num_classes; class_index++)
    printf("%f ",determinant[class_index]);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         for(class_index=1; class_index <= lu_vc~>num_classes; class_index++)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     printf("\nThese are the natural logs of the determinants:\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     ", log_det[class_index]);
                                                                                                                                       for(row=1; row <= lu_vc->num_rows; row++)
                                                                                                                                                                                                                                                                                                                                                                                                                              printf("These are the determinants:\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     printf("%f
                                                                                                                                                                                                                                                                                                                                                                                  #ifdef DET DEBUG
#endif
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     #endif
```

```
inv_vc->array = f3tensor(1, inv_vc->num_classes,
                                                                                                                                                                                1, inv_vc->num_rows,
                                                                   inv_vc->num_classes = vc->num_classes;
                                                                                                     inv_vc->num_bands = vc->num_bands;
                                     inv vc->num cols = vc->num cols;
inv_vc->num_rows = vc->num_rows;
```

 $/\star$ Calculate the matrix inverses from the LU decomposed matrices $\star/$

```
free_matrix(mean->array,0,mean->num_rows-1,0,mean->num_cols-1);
                                                                                                                                                                                                                                                                                                                                                                                                                                             status=write_output(stats_filename, mean, inv_vc, vc, log_det,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      AVS_VALUE | AVS_MINVAL | AVS_MAXVAL,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 free_ivector(length,0,pixel_list->num_classes -1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          free_f3tensor(inv_vc->array,1,inv_vc->num_classes,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       1, inv vc->num cols);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     free_f3tensor(lu_vc->array,1,lu_vc->num_classes,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  1, inv_vc->num_rows,
                                                                                                                                                /\star update the display with the elapsed time \star/
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     /* free all the previously allocated memory */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           1,lu vc->num cols);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             free_imatrix(index,1,lu_vc->num_classes,1,n);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          1,lu_vc->num_rows,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      free_f3tensor(vc->array,0,vc->num_classes-1,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                0, vc->num cols-1);
                                                                                                                                                                                                                      time = (int) (after.tv sec-before.tv sec);
                                                                                                                                                                                                                                                           AVSmodify parameter("Elapsed time (sec):",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           0, vc->num rows-1,
                                                                                                                                                                                                                                                                                                                                                                                                        /* write the output to the disk file */
                                                                                                                                                                                                                                                                                                                                     time, time, time);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     determinant);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      free_vector(determinant,1,n);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                free_vector(col_vector,l,n);
                                                                                                                                                                                     gettimeofday(&after, NULL);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               free_vector(log_det,l,n);
printf("\n");
                                                                         #endif
```

printf("%f ",lu_vc->array[class_index][row][col]);

for(class_index=1; class_index <= lu_vc->num_classes; class_index++){

for(row=1; row <= lu_vc->num_rows; row ++) {
 for (col = 1; col <= lu_vc->num_cols; col++)

printf("\n");

printf ("\n");

```
printf("ERROR: Unable to malloc norm_vector_trans pointer.\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                printf("ERROR: Unable to malloc norm_vector pointer.\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        printf("ERROR: Unable to malloc temp matrix pointer.\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           printf("ERROR: Unable to malloc sum matrix pointer.\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   for (class_index=0; class_index < vc->num_classes; class_index++)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              printf("Unable to malloc product matrix pointer.\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               vc->array[class_index][row][col]=0.0;
                                                                                                                                                                                                                                                                                                                                                                                  /* indicate failure until we know better */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         norm_vector_trans = (matrix_ptr)malloc(sizeof(MAT_STRUCT));
                                                                                                                                                                                              matrix_ptr temp, sum, product, norm_vector, norm_vector_trans;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          for (col=0; col < vc->num_bands; col++)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            norm_vector = (matrix_ptr)malloc(sizeof(MAT_STRUCT));
                                                                          int calc_vc_matrix(pix_list_ptr pixel_list, matrix_ptr mean,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    product = (matrix_ptr)malloc(sizeof(MAT STRUCT));
                                                                                                                                                                                                                                                                     register int class index, row, col, pix_num, band index;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    temp = (matrix_ptr)malloc(sizeof(MAT_STRUCT));
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       sum = (matrix_ptr)malloc(sizeof(MAT_STRUCT));
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     for(row=0; row < vc->num_rows; row++)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     vc->num_cols = pixel_list->num_bands;
vc->num_rows = pixel_list->num_bands;
vc->num_bands = pixel_list->num_bands;
vc->num_classes = pixel_list->num_classes;
vc->num_classes = pixel_list->num_classes=1,
vc->array = fistensor(0, vc->num_classes=1,
0,vc->num_rows=1,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      0, vc->num cols-1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          /* Set up storage for the vc matrix */
                                                                                                                                                                                                                                                                                                                                                                                                                                                      /* malloc the structure pointers */
                                                                                                                       three d matrix ptr vc) (
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 /* initialize the vc matrix */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           if (norm_vector trans==NULL) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 if (norm_vector==NULL) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      (product==NULL) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            return(1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       return(1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              return(1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       return(1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 return(1);
                                                                                                                                                                                                                                   int target_class, status;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   if (temp==NULL) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            if (sum-=NULL) {
                                                                                                                                                                                                                                                                                                           float denom, value;
                                                                                                                                                                                                                                                                                                                                                                                      status=0;
                                                                                                                                                                                                                                                                                                 This routine calculates the mean vector and number of elements for each
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   mean->array[row][col]/=mean->array[row][mean->num_cols-1];
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                printf("\nMean matrix with num_elements in each class appended:\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 class_index=pixel_list->array(pix_num)[mean->num_cols-1];
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  pixel_list->array[pix_num][col];
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      This routine calculates the variance-covariance matrix for each
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            for(pix_num=0; pix_num < pixel list->num pixels; pix num++){
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              /\star debug code - print out the mean matrix \star/
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                mean->array=matrix(0,mean->num_rows-1,0,mean->num_cols-1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                mean->array[class_index][mean->num_cols-1]+=1.0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 int calc_mean_vectors(pix_list_ptr pixel_list, matrix_ptr mean)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             printf("%f ",mean->array[row][col]);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                for(col=0; col < mean->num_cols-1; col++)
    mean->array[class_index][col]+=
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        for(row=0; row < mean->num_rows; row++)
for(col=0; col < mean->num_cols-1; col++)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      for(row=0;row < mean->num_rows; row++)
for(col=0; col < mean->num_cols; col++)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       for(col=0; col < mean->num_cols; col++)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      /\star Need to normalize the individual vectors \star/
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    /\star Initialize the mean matrix with zeros \star/
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     mean->array[row][col]=0.0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  for(row=0; row < mean->num_rows; row++) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         mean->num_rows=pixel_list->num_classes;
mean->num_cols=pixel_list->num_bands+1;
                                                                                                                                                                                                                                                           Function calc mean vector
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     register int row, col, pix_num;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        }/* end of calc_mean_vectors */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          Function calc_vc_matrix
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               printf("\n");
                                                                       /* End of Main */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              int status, class_index;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      return(status);
                                                                                                                                                                                                                                                                                                                                                                        training class
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           training class
return(1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          #ifdef MEAN DEBUG
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    status=1;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         #endif
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                --×/
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               A-18
```

Filename: AVS classtat.c

```
#endif
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              - mean->array[target_class][band_index];
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   pixel_list->array(pix_num)(band_index)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      product->array = matrix(0,product->num_rows-1,0,product->num_cols-1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        sum->array[row][col];
                                                                                                                                                                                                                                                                                                                                                                                                                                                                        0, norm_vector_trans->num_cols-1);
                                                                                                                                                                                                                                                                                                                                                                                                                     norm_vector_trans->array = matrix(0, norm_vector_trans->num_rows-1,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              norm_vector->array[band_index][0];
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     /* move vc[band] into structure to pass to add_matrices */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            target_class=pixel_list->array[pix_num][pixel_list->num_bands];
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       mult_matrices(norm_vector, norm_vector_trans, product);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              MUST set up storage for the matrix multiplication result ^{\star}/
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               printf("This pixel belongs to class %d.\n", target class); printf("\nThis is the result of the call to mult_matrices\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 /* read the sum back into the appropraite vc array */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 for(band_index=0; band_index < vc->num_bands; band_index++) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        printf("Currently processing pixel number %d.\n", pix_num);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              vc->array[target_class][row][col]=
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         sum->array = matrix(0, sum->num_rows-1,0, sum->num_cols-1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            /\star MUST set up storage for the matrix addition result \star/
                                                                                                                                                                                       0, norm_vector->num_cols-1);
                                                                                                                                    norm_vector->array = matrix(0,norm_vector->num_rows-1,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               for (col=0; col < vc->num_cols; col++)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             for(pix_num=0; pix_num < pixel_list->num_pixels; pix_num++){
/\star set up the storage for the normalized vector \star/
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        norm_vector_trans->array[0][band_index]=
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                for(row=0; row < vc->num_rows; row++)
                                                                                                                                                                                                                                                                                                                                                                          norm_vector_trans->num_cols = vc->num_bands;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    temp->array=vc->array[target_class];
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     norm_vector->array[band_index][0]=
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       add_matrices(temp, product, sum);
                                              norm_vector->num_rows = vc->num_bands;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   temp->num rows=vc->num rows;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             temp->num cols=vc->num cols;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        product->num_rows = vc->num_bands;
product->num_cols = vc->num_bands;
                                                                                                                                                                                                                                                                                                                                norm vector trans->num rows = 1;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             ) /* end of band_index loop */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           sum->num_rows = vc->num_bands;
sum->num_cols = vc->num_bands;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  /* calculate (x-u)*(x-u)^T */
                                                                                         norm vector->num cols = 1;
                                                                                                                                                                                                                                                                            /* and its transpose */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  #ifdef SUBVC DEBUG
```

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printf("%f ",vc->array[class_index][row][col]);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              printf("%f ",vc->array[class_index][row][col]);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   printf("\nThese are the values of the elements in the vc matrix\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    /* divide elements by one less than the num_elements in the class */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                value = (float)mean->array[class_index][pixel_list->num_bands];
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      for(class_index=0; class_index < vc->num_classes; class_index ++)(
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      for(class index=0; class index < vc->num classes; class index++) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           printf("\nThese are the vc matrices after normalization:\n\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     for(class_index=0; class_index<vc->num_classes; class_index++)(
                                                                                                                                                                                                              printf("\nThis is the result of the call to add matrices\n");
printf("%f\t", product->array[row][col]);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        vc->array[class_index][row][col]/=denom;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         free_matrix(norm_vector->array,0,norm_vector->num_rows-1,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               printf("Normalizing the elements of the vc matrix.\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  /* free all the allocated memory, order is important ^{\star}/
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        for(col=0; col < vc->num_cols; col++)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       for(col=0; col < vc->num_cols; col++)
                                                                                                                                                                                                                                                                                                                                                                                 printf("%f\t", sum->array[row][col]);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             for(col=0; col < vc->num cols; col++)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         for(row=0; row < vc->num_rows; row++) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   for(row=0; row < vc->num_rows; row++) {
                                                                                                                                                                                                                                                                                                                                          for(col=0; col < sum->num_cols; col++)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      for(row=0; row < vc->num rows; row++)
                                                                                                                                                                                                                                                                                                   for(row=0; row < sum->num rows; row++) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      } /* end of class index loop */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     printf("\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 printf("\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           denom = value-1.0;
                                      printf("\n");
                                                                                                                                                                                                                                                                                                                                                                                                                            printf("\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    printf("\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       printf("\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  ) /* end of pix_num loop */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    printf("\n");
                                                                                                                                                                   printf("\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    #ifdef DEBUG
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            #endif
```

for(col=0; col < product->num_cols; col++)

for(row=0; row < product->num_rows; row++) {

```
_
                                   free_matrix(norm_vector_trans->array,0,norm_vector_trans->num_rows-1,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  matrix, its determinant, and its inverse to a user defined disk file. Function will happily cream any disk file with the same name as the
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        this function writes the mean vector matrix, The variance-covariance
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               int write_output(char *filename, matrix_ptr mean, three_d_matrix_ptr inv_vc, three_d_matrix_ptr vc, float *log_det, float *determinant)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      AVSmessage("beta", AVS_Error, NULL, "Class Statistics", "Okay", "Clould not create: %s\n",fillename);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       fprintf(out_file, "training class statistics file for AVS GML\n");
                                                                      0, norm_vector_trans->num_cols-1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        fprintf(out_file,"%f ",mean->array[row][col]);
                                                                                                                                                                          free_matrix(sum->array,0,sum->num_rows-1,0,sum->num_cols-1);
0, norm_vector->num_cols-1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           classes\n",inv_vc->num_classes);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          bands/n", inv vc->num bands);
                                                                                                                                   0, product->num_cols-1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    fprintf(out_file, "These are the mean vectors:\n");
                                                                                                   free_matrix(product->array,0,product->num_rows-1,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     for(col=0; col < mean->num_cols; col++)
                                                                                                                                                                                                                                                                                                                                                                                                                          /* We're done, let's jam */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 for(row=0; row < mean->num_rows; row++) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    /* print the file verification header */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   /* assume failure */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           /\star print the inverted vc matrices \star/
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                out_file = fopen(filename, "w");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        fprintf(out_file,"\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              /* print the mean vectors */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            register int row, col, class_index;
                                                                                                                                                                                                          free(norm_vector);
free(norm_vector_trans);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           } /* end of calc_vc_matrix */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        Function write_output
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                if(out_file == NULL) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       fprintf(out_file,"%d
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              fprintf(out file,"%d
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             return(1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 rewind(out file);
                                                                                                                                                                                                                                                                                                                                                                                                                                                              return(status);
                                                                                                                                                                                                                                                                                                                    free (product);
                                                                                                                                                                                                                                                                                                                                                       free (temp);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                char response[128];
                                                                                                                                                                                                                                                                                free (sum);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   status=0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         FILE *out_file;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               int status;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     A-20
```

```
fprintf(out_file,"These are the inverted matrices:\n");
for(class_index=1; class_index <= inv_vc->num_classes; class_index ++){
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                inv_vc->array[class_index][row][col]);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                             fprintf(out_file, "These are the natural logs of the determinants:\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      for(class_index=1; class_index <= inv_vc->num_classes; class_index ++)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             fprintf(out_file, "\nThese are the normalized vc matrices:\n\n");
for(class_index=0; class_index < vc->num_classes; class_index ++){
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        fclose(out_file); printf("The statistics file was successfully written to disk.\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     vc->array[class_index][row][col]);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          fprintf(out_file,"%f ", determinant[class_index] );
                                                                                                              for(row=1; row <= inv_vc->num rows; row++) {
   for(col=1; col <= inv_vc->num_cols; col++)
   fprintf(out_file,"%f ",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       for(col=0; col < vc->num_cols; col++)
fprintf(out_file, "%f ",
                                                                                                                                                                                                                                                                                                                                                                                                                                         /* print out the natural log of the determinants */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               fprintf(out_file, "These are the determinants:\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       for(row=0; row < vc->num_rows; row++) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         /* print out the normalized vc matrices */
                                                                                                                                                                                                                                                                             fprintf(out_file, "\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         fprintf(out_file, "\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       fprintf(out file, "\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            /* print out the determinants */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      /* end of write_output */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 fprintf(out_file, "\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           fprintf(out_file, "\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 /* return success */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               return(status);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        status=1;
```

```
Last Updated: Thu Aug 31 01:16:30 1995
```

typedef CLASS_MAP *class_map_ptr;

/* this is the inv_vc matrix */

float *nlog_determinant;

int num_rows; int num_cols;

float ***array;

typedef struct{

int num_classes;

int num bands;

```
file with a mean vector and a variance covariance matrix for each class. This
This program performs Gaussian Maximum Likelihood (GML) on an image given a
                                                                                                                                                                                                                                                                              support added to read statistics file
                                                                             file can be created with the classtat program (another AVS module).
                                                                                                                                                                                                                                                                                                                                                        more filename handling enhancements
                                                                                                                                                                                                                                                                                                                                                                                                        handles images that are NOT square
                                                                                                                                                           Nessmiller, Steven W.
                                                                                                                                                                                                Date of last revision: 16 April 1995
                                                                                                                                                                                                                                         7 May 1995 -
                                                                                                                                                                                                                                                                                                                       20 May 95 -
                                                                                                                                                                                                                                                                                                                                                                                                                                             29 June 95
```

```
/* layered debug definitions */
                                                                                                                                           #include <avs/avs_data.h>
                                                                                                                                                               #include <avs/field.h>
                                                                                                                                                                                    #include <avs/flow.h>
#include "memutil.h"
#include "imat.h"
                                                                                             #include <sys/time.h>
                                                                                                                   #include <avs/avs.h>
                                             #include <stddef.h>
                                                                                                                                                                                                                                                                                                        #define HUGEMHD 600
                     #include <stdlib.h>
                                                                     #include <stdio.h>
#include <math.h>
                                                                                                                                                                                                                                                                                #define MAXSTR 80
                                                                                                                                                                                                                                                                                                                                                                              #define DEBUG
```

```
/* this structure supports the input image */
typedef struct{
                                                                           #define HIGHPROCESS_DEBUG
                                                                                                      #define LOWPROCESS DEBUG
                                                                                                                                                                                                                                        int num_rows;
#define STATS DEBUG
```

```
typedef IMG_STRUCT *image_ptr;
int num_cols;
int num_bands;
                                   } IMG_STRUCT;
```

```
/\star this structure supports the classification map ^{\star}/
                                                                                                               int num_classes;
                                                                                        int num_cols;
                                                                 int num_rows;
                                                int **array;
                       typedef struct{
                                                                                                                                      CLASS MAP;
```

Filename: AVS gml.c

```
in_port = AVScreate_input_port( "Input Image", "field 2D uniform byte",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             "field 2D uniform float", REQUIRED );
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     "GML Classification Parameters:", "", "");
                                                                                                                                                                       int get_stats(char *filename, matrix_ptr mean, three_d_matrix_ptr inv_vc);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   AVSset_module_name("GML Classification", MODULE_FILTER);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    AVSadd_parameter_prop(param,"width","integer",4);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             out_port = AVScreate_output_port( "Class Image",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              REQUIRED );
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     param = AVSadd_parameter("head", "string",
                                                                                                                                                                                                                                                                         AVSfield_char *input_image,
                                                                                                                                                                                                                                                                                                                                                                                                                                             int interface_skip_zeros);
                                                                                                                                                                                                                                                                                                                                                                              three d matrix ptr inv vc,
                                                                                                                                                                                                                                                                                                                                                                                                                 class_map_ptr classified,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               /\star set up the input windows and buttons \star/
                                                                  typedef D3_MAT_STRUCT *three_d_matrix_ptr;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          AVSconnect_widget(param, "text");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     AVSmodule_from_desc (AVS_gml);
                                                                                                                                                                                                                                      int process_image(float chi_squared,
                                                                                                                                                                                                                                                                                                            image_ptr input,
                                                                                                                                                                                                                                                                                                                                               matrix ptr mean,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    /* set the module name and type */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               int in port, out port;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           /* create the output port */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      /* create the input port */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 int GML_compute();
                                                                                                                                 /* function prototypes */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  char cwd[MAXSTR];
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  int AVS_gml();
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            int param;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   AVSinit_modules()
D3_MAT_STRUCT;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          AVS_gml()
```

/* create a window to select the statistics filename */

getwd(cwd);

```
image_ptr input;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               matrix ptr mean;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       param =AVSadd_float_parameter("Chi squared:", 12.8, 1.0, FLOAT_UNBOUND);
                                                                                                                                       param=AVSadd_parameter("Statistics file (*.sta):","string",cwd,0,".sta")
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              param=AVSadd_parameter("Number of classes:","integer",0,0,INT_UNBOUND);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           param=AVSadd_parameter("Number of bands:","integer", 0, 0,INT_UNBOUND);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              /\star create a widget to display the percentage of the image that is classified \star/
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 param =AVSadd_float_parameter("Percent classified:", 0.0, 0.0, 100.0);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     param=AVSadd_parameter("Skip zero vectors", "boolean", 0, 0, 0);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             param=AVSadd_parameter("Auto-generate GML", "boolean", 0, 0, 0);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            param=AVSadd_parameter("Generate GML map", "oneshot", 0, 0, 0);
                                                                                                                                                                                                                                                                                                                                                                                                                                   param=AVSadd_parameter("View all file types", "boolean", 0, 0, 1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  param=AVSadd_parameter("Elapsed time (sec):","integer",0,0,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       create an output window to display the number of classes */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 AVSadd_parameter_prop(param, "width", "integer", 4);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            AVSadd_parameter_prop(param, "width", "integer", 4);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         AVSadd_parameter_prop(param, "width", "integer", 4);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           /* create an output window to display the number of bands */
                                                                                                                                                                                                                                       AVSadd_parameter_prop(param, "width", "integer", 4);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               AVSadd_parameter_prop(param,"width","integer",2);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                               AVSadd_parameter_prop(param,"width","integer",4);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  AVSadd_parameter_prop(param,"width","integer",2);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             AVSadd_parameter_prop(param, "width", "integer", 2);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 create an output window to display elapsed time */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     create a widget to generate the GML class map ^{\star}/
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               AVSconnect widget(param, "typein_integer");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  AVSconnect_widget(param,"typein_integer");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             AVSconnect_widget(param,"typein_integer");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          AVSconnect_widget(param, "typein_real");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           AVSconnect_widget(param, "typein_real");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               create a widget to get chi squared value */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 create a widget to permit autogeneration */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  INT UNBOUND);
                                                                                                                                                                                                                                                                                   AVSconnect_widget(param, "browser");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     AVSconnect_widget(param, "toggle");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             AVSconnect_widget(param, "toggle");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     /* create a widget to skip zero vectors */
                                                                                                                                                                                                                                                                                                                                                                                   /* allow user to view all file types */
if( cwd[strlen(cwd)-1] != '/')
                                       streat(cwd,"/");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            /* free the output data */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               *
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   *
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 *
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     *
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             *
```

```
AVS_VALUE, stats_filename, 0, 0);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     printf("Allocating structures for statistics file read.\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     inv_vc = (three_d_matrix_ptr)malloc(sizeof(D3_MAT_STRUCT));
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        printf("ERROR: Unable to malloc inv_vc pointer\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               AVS_VALUE|AVS_MAXVAL, "/tmp/", 0, ".sta"); printf( "Setting maxval to .sta\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     AVSmodify parameter("Statistics file (*.sta):",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         AVSmodify_parameter("Statistics file (*.sta):",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     AVSmodify_parameter("Statistics file (*.sta):",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  AVSmodify_parameter("Statistics file (*.sta):",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         AVS VALUE | AVS MAXVAL, "/tmp/",0,"");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            AVS_VALUE, stats_filename, 0, 0);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         printf( "Setting maxval to null\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  /* allocate memory for the structures */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  if(AVSparameter_changed("View all file types")){
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               /* check for view all parameter filenames */
                                                                                                                                                                                                                                                                            float *interface_percent_classified,
                               AVSfield_float **output_image,
                                                                                                                                                                      float *interface_chi_square,
int GML compute (AVSfield char *input image,
                                                                                                                                                                                                         int interface num_classes,
                                                                                                                                                                                                                                                                                                                                                   int interface_skip_zeros,
                                                                                                                                                                                                                                            int interface_num_bands,
                                                                                                   char *stats_filename,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        if (inv_vc == NULL) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            static char old stats filename[80];
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         static int first_time_through = 1;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               return(1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               char *reset stats filename = " ";
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            static int valid_stats_file = 0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  if(first_time_through) (
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         struct timeval before, after;
                                                                                                                                                                                                                                                                                                                                                                                   int auto_run,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         int value, dims[2], status;
                                                                      char *head,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               three_d_matrix_ptr inv_vc;
                                                                                                                                                                                                                                                                                                                   int time,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         class_map_ptr classified;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  if (all) {
                                                                                                                                         int all,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      register int row, col;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               else{
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      /* local variables */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  float chi squared;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         FILE *input_file;
```

/* set the function to create the output */

AVSautofree_output(out_port);

AVSset_compute_proc(GML_compute);

Filename: AVS gml.c

```
else (
                                                                                                                                                    #ifdef DEBUG
                                                                                                                                                                                                                                                                                                                                                                                 #endif
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               inv_vc->num_classes, inv_vc->num_classes, inv_vc->num_classes);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         "Okay", "Couln not open file %s.\n", stats_filename);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     valid_stats_file = get_stats(stats_fillename, mean, inv_vc);
                                                                                                                                                    printf("ERROR: Unable to malloc mean pointer\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      AVSmessage ("beta", AVS_Error, NULL, "GML Classification",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                inv_vc->num_bands, inv_vc->num_bands, inv_vc->num_bands);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            free_f3tensor(inv_vc->array,0,inv_vc->num_classes-1,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          /* update the interface with the data from the file */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    0, inv_vc->num_cols-1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              0, inv_vc->num_rows-1,
                                                                                                                                                                                                                                                                                                                                                                                                                                                          /* ensure that we have a file and NOT just a directory */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    0, mean->num_cols-1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               /* get the mean and vc matrices from the file */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              free_matrix(mean->array,0,mean->num_rows-1,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            if(stats_filename[strlen(stats_filename) - 1] == '/'){
                                                                            mean = (matrix_ptr)malloc(sizeof(MAT_STRUCT));
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   AVSmodify_parameter("Number of classes:",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      status = strcmp(stats_filename, old_stats_filename);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      printf("Freeing the inv_vc matrix.\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        AVSmodify parameter ("Number of bands:",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        printf("Freeing the mean matrix.\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     strcpy(old_stats_filename, stats_filename);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       input_file = fopen(stats_filename, "r+");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    /* see if the statistics file has changed */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      AVS_VALUE | AVS_MINVAL | AVS_MAXVAL,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              AVS_VALUE | AVS_MINVAL | AVS_MAXVAL,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                /* free memory if necessary */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                if (inv vc->array != NULL) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      if (mean->array != NULL) (
                                                                                                                                                                                                                                                                                                                                           first_time_through = 0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           valid_stats_file = 0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             if(valid_stats_file){
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   valid_stats_file = 0;
inv_vc->array = NULL;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                if(input_file == NULL) {
                                                                                                                                                                                                                                                                   mean->array = NULL;
                                                                                                              if (mean === NULL) {
                                                                                                                                                                                          return(1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         return(1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        return(1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               if (status != 0) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             else{
```

```
/* check to make sure that the parameter file and the image jive */
if (input->num_bands != inv_vc->num_bands) {
    AVSmessage("beta",AVS_Error, NULL, "GML Classification","Okay",
    "The input image and the statistics file are NOT compatible.");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             and percent classified from last run \star/
                                                                                                                                                                                                                                                                                                                                                                                             AVSmodify_parameter("Generate GML map", AVS_VALUE, 0, 0, 0);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       printf("ERROR: Unable to malloc classified image pointer\n");
                                           printf("The value of Chi squared is %f\n", *interface chi square);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     printf("ERROR: Unable to malloc input image pointer.\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               AVS_VALUE | AVS_MINVAL | AVS_MAXVAL, 0.0, 0.0, 0.0);
                                                                                   printf("Number of classes = %d and number of bands = %d.\n",
printf("The statistics filename is %s.\n", stats_filename);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    AVS_VALUE | AVS_MINVAL | AVS_MAXVAL,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    classified = (class map ptr)malloc(sizeof(CLASS MAP));
                                                                                                                                                                          printf("run = %d autorun = %d.\n", run, auto_run);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          stropy(old_stats_filename, reset_stats_filename);
                                                                                                                                   inv vc->num classes, inv vc->num bands);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          /* allocate memory for the structure pointers */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        AVSmark_output_unchanged("Class Image");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           AVSmodify_float_parameter("Percent classified:",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              input = (image_ptr)malloc(sizeof(IMG_STRUCT));
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            /* set up some variables that we'll need */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         AVSmodify_parameter("Elapsed time (sec):",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               input->num_bands = input_image->veclen;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        input->num_rows = MAXY(input_image);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               input->num_cols = MAXX (input_image);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          /* reset the static variables */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             /* clear out the elapsed time
                                                                                                                                                                                                                                                                                                                                             if ( run && valid_stats_file )
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                0, 0, 0);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            if (classified == NULL) (
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      first time through = 1;
                                                                                                                                                                                                                                                                                                         /* check if run time */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          valid stats file = 0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         if(input == NULL){
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           return(1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       return(1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     return(1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     return(1);
```

```
"Okay", "%s is NOT a valid GML statistics file",filename);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  AVSmessage ("beta", AVS_Error, NULL, "GML Classification", "Okay", "Unable to open statistics file: %s",filename);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               int get_stats(char *filename, matrix_ptr mean, three_d_matrix_ptr inv_vc)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                AVSmessage ("beta", AVS_Error, NULL, "GML Classification",
                                                                     /* free all the allocated memory, order is VERY IMPORTANT!!!!*/
                                                                                                                                                                                                                                                                                                                                                                                                     free_matrix(mean->array,0,mean->num_rows-1,0,mean->num_cols-1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   char *valid = "training class statistics file for AVS GML\n";
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      printf("The requested statistics file was located\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                reads in the stats file and assigns a pointer to it.
                                                                                                                                                                                                                                                      free_f3tensor(inv_vc->array,0,inv_vc->num_classes-1,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 (void) fgets(line, sizeof(line), in_file);
                                                                                                                                                                                0, classified->num_cols-1);
                                                                                                                                               0, classified->num_rows-1,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                           /* now free the structure pointers */
                                                                                                                                                                                                                                                                                                                               0, inv_vc->num_cols-1);
                                                                                                                                                                                                                                                                                          0, inv_vc->num_rows-1,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         register int row, col, class_num;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               /* check for proper file type */
                                                                                                          free_imatrix(classified->array,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              in_file = fopen(filename,"r");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     status = strcmp(line, valid);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    int classes, bands, status;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           fclose(in file);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    if (!in_file) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             /* return success */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  return(-1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          return(-1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 char line[MAXSTR];
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          if (status != 0) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 free (classified);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        FILE *in file;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     free (inv vc);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                free (input);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             free (mean);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     return(1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  function get_stats
#endif
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     status=process_image(chi_squared, input_image, input, mean, inv_vc,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          I2D(*output_image, col, row) = classified->array[row][col];
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              *output_image = ( AVSfield_float * )
( AVSdata_alloc( "field 2D uniform scalar float", dims ));
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 ( AVSdata_alloc( "field 2D uniform scalar float", dims ));
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                AVSmodify_parameter("Elapsed time (sec):",
AVS_VALUE | AVS_MINVAL | AVS_MAXVAL,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   classified, interface_skip_zeros);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        ( dims[ 1 ] := MAXX( *output_image ) ) (
AVsfield_free( (AVsfield *) *output_image );
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          time = (int) (after.tv_sec - before.tv_sec);
printf("All pixels processed in %d seconds.\n",time);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     for (col=0; col < classified->num_cols; col++) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            /* copy the classification map to the output port */
                                                                                                                                                                                                                                                                                                                                                                                                  0, classified->num_cols-1);
                                                                                                                                                                                                                                                                                    classified->num_rows=input->num_rows;
classified->num_cols=input->num_cols;
classified->array=imatrix(0, classified->num_rows-1,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          else if ( ( dims[ 0 ] != MAXX( *output_image ) ) ||
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         printf("Status error in process_image\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 for (row=0; row < classified->num_rows; row++) {
                                                                                                                                                                                                                     /* set up memory for the classification map */
                                                                                                                                                                                                                                                      classified->num_classes = inv_vc->num_classes;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                           /* calculate each pixel's class membership */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  /* set up storage for the output image */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   *output_image = ( AVSfield_float * )
                                                                                                       printf("All structures allocated.\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            time, time, time);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             chi_squared = *interface_chi_square;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 printf("output field allocated\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           if ( *output_image == NULL ) (
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                gettimeofday(&before, NULL);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            gettimeofday(&after, NULL);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       printf("Field written\n" );
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                dims[0] = input->num_cols;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        dims[1] = input->num_rows;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     return(1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        if (status!=1) {
                                                                     #ifdef DEBUG
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             #ifdef DEBUG
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      #ifdef DEBUG
                                                                                                                                           #endif
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      #endif
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              A-24
```

Filesize: 25.48 kbytes

Filename: AVS_gml.c

```
for (row=0; row < mean->num rows; row++)
for (col = 0; col < mean->num_cols; col++)
                                                                                                                                                                                                                                                                                                                                       /* read in the values */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   /* read in the values */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 printf("\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                printf("\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              fclose(in file);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          return(status);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        Function process_image
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  printf("\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           #endif
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        printf("The number of classes in the data = %d\n", inv_vc->num_classes);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 printf("ERROR: unable to malloc in of determinant matrix.\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         /* total number of pixels in class */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 printf("The num rows in each inv_vc matrix = %d\n",inv_vc->num_rows);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              printf("The num cols in each inv vc matrix = %d\n",inv vc->num cols);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             (void) fgets(line, sizeof(line), in_file); /* skip the mean heading */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           printf("The num columns in the mean matrix = %d\n", mean->num cols);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          printf("The number of bands in the data = %d\n",inv_vc->num_bands);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  printf("The num rows in the mean matrix = %d\ln", mean->num_rows);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      /* malloc the memory for the mean matrix and check its status */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       /* Echo the header information just read in */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        mean->array = matrix(0, mean->num_rows-1,0, mean->num_cols-1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            printf("ERROR: unable to malloc inv_vc matrix.\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          inv_vc->nlog_determinant = vector(0,inv_vc->num_classes-1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  printf("ERROR: unable to malloc mean matrix.\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              printf("Statistics file file being read into memory\n");
                                                                                                                                                                                                                                                                                                                                                                                                                      /* asssign the values to the structure elements */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 inv_vc->array ~ f3tensor(0,inv_vc->num_classes-1,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         printf("Statistics file header information: \n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        0, inv_vc->num_cols-1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           0, inv_vc->num_rows-1,
                                                                                                                                                                                                               (void) fgets(line, sizeof(line), in_file);
                                                                                                                                                                                                                                                                                                  (void) fgets(line, sizeof(line), in file);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        printf("Processing the mean matrix\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           if (inv_vc->nlog_determinant == NULL) {
                                                                                          /* assume success */
                                                                                                                                                                         /* read in the rest of the header */
                                                                                                                                                                                                                                                                                                                                       (void) sscanf(line, "%d", &classes);
                                                                                                                                                                                                                                                        (void) sscanf(line, "%d", &bands);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              inv_vc->num_classes = classes;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          if (inv vc->array == NULL) (
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       inv_vc->num_bands = bands;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         mean->num_cols = bands+1;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               inv_vc->num_rows = bands;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                    mean->num rows = classes;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        inv_vc->num_cols = bands;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         if (mean->array == NULL) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       /* read in the values */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  return(status);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      return(status);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    return(status);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        status = 0;
                                                                                          status = 1;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   #ifdef STATS DEBUG
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   #end1f
```

```
#ifdef STATS_DEBUG /* Debug code - echo the matrix values to maintain sanity */
fscanf(in_file, "%f", &mean->array[row][col]);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     /* read in the natural log of the determinants */
/* the file pointer has not seen the EOL yet! */
(void)fgets(line, sizeof(line), in_file;/* move it to the next line */
(void)fgets(line, sizeof(line), in_file;/* skip the matrix heading */
                                                                                                                                                                                                                      (void)fgets(line,sizeof(line),in_file);/* move it to the next line */
(void)fgets(line,sizeof(line),in_file); /* skip the matrix heading */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           fscanf(in_file, "%f", &inv_vc->nlog_determinant(class_num));
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             fscanf(in_file, "%f", &inv_vc->array[class_num][row][col]);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              printf("%2f ",inv_vc->array[class_num][row][col]);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  (void)fgets(line, sizeof(line), in_file); /* skip the matrix heading
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  for (class_num=0; class_num < inv_vc->num_classes; class_num++)
                                                                                                                                                                                                                                                                                                                                                                                          for (class_num=0; class_num < inv_vc->num_classes; class_num++)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       for (class_num=0; class_num < inv_vc->num_classes; class_num++)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     for (class_num=0; class_num < inv_vc->num_classes; class_num++)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     printf("%2f ",inv_vc->nlog_determinant[class_num]);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          for (col = 0; col < inv_vc->num_cols; col++)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           for (col = 0; col < inv vc->num cols; col++)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          printf("These are the natural logs of the determinants:\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 printf("Training statistics successfully read in.\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           printf("%2f ", mean->array[row][col]);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             for (row=0; row < inv_vc->num_rows; row++) (
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        for (col = 0; col < mean->num_cols; col++)
                                                                                                                                                                                                                                                                                                                                                                                                                                             for (row=0; row < inv_vc->num_rows; row++)
                                                                                                                                                                   /* the file pointer has not seen the EOL yet! */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  printf("These are the inverted vc matrices:\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           This function produces the classification map
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          for (row=0; row < mean->num_rows; row++) {
                                                                                                                printf("Processing the inv_vc matrix\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             printf("These are the mean vectors:\n");
```

Filename: AVS gml.c

```
spectral_vector->array[0][band] = (float)(*(12DV(input_image,col,row)+band))
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  product1->array=matrix(0, product1->num_rows-1,0, product1->num_cols-1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    product2->array-matrix(0,product2->num_rows-1,0,product2->num_cols-1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           /* MUST set up storage for the second matrix multiplication result */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          /\star MUST set up storage for the first matrix multiplication result \star/
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               0, norm_vector_trans->num_cols-1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       norm_vector_trans->array = matrix(0, norm_vector_trans->num_rows-1,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                for(band = 0; band < input->num_bands; band++) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                /* load each pixel into the spectral vector */
                                                                                                                                                                                              printf("Unable to malloc product2 matrix pointer\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 0, spectral_vector->num_cols-1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        spectral_vector->array=matrix(0, spectral_vector->num_rows-1,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       /\star reset the value of smallest, its index, and assigned \star/
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 0, norm_vector->num_cols-1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         norm_vector->array = matrix(0,norm_vector->num_rows-1,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                for(col = 0; col < input->num_cols; col++)(
                                                                                                                                                                                                                                                                                                                                                                                                                                    /* set up the storage for the normalized vector */
                                                                                                                 product2 = (matrix ptr)malloc(sizeof(MAT_STRUCT));
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          norm_vector_trans->num_rows = input->num_bands;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       for (row = 0; row < input->num_rows; row++) (
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    spectral_vector->num_cols=input->num_bands;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                norm vector->num cols = input->num bands;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     magnitude += spectral_vector->array[0][band];
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      product1->num_rows = 1;
product1->num_cols = input->num_bands;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     /* classify the entire input image */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   row_step = 1.0 / input->num_rows;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      norm_vector_trans->num_cols = 1;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        magnitude = 0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       /* and the spectral vector */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   spectral_vector->num_rows=1;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               smallest - HUGEMHD;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                norm_vector->num_rows = 1;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       smallest_index=0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     /* and its transpose */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       product2->num_rows = 1;
return(status);
                                                                                                                                                                                                                                                                              return(status);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               product2->num_cols = 1;
                                                                                                                                                         if (product2 == NULL) (
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            assigned = 0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          num_classified = 0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  stage = 0.10;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   if (spectral_vector == NULL) {
    printf("Unable to malloc spectral_vector transpose pointer\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    printf("Unable to malloc norm_vector transpose pointer\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  printf("Unable to malloc norm_vector matrix pointer\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            printf("Unable to malloc product1 matrix pointer\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       norm_vector_trans = (matrix_ptr)malloc(sizeof(MAT_STRUCT));
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  spectral_vector = (matrix_ptr)malloc(sizeof(MAT_STRUCT));
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             printf("Unable to malloc psi matrix pointer\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             /* set up storage for each matrix structure pointer*/ \,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         norm_vector = (matrix_ptr)malloc(sizeof(MAT_STRUCT));
if (norm_vector == NULL) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               product1 = (matrix_ptr)malloc(sizeof(MAT_STRUCT));
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          int smallest_index, assigned, num_classified, magnitude;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               float percent_classified, percent_done, row_step, stage;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                psi = (matrix_ptr)malloc(sizeof(MAT_STRUCT));
if (psi == NULL)(
                                                                         AVSfield char *input_image,
                                                                                                                                                                                              three_d_matrix_ptr inv_vc,
                                                                                                                                                                                                                                      class_map_ptr classified,
                                                                                                                                                                                                                                                                       int interface_skip_zeros)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              register int row, col, band, class_num, x;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        if (norm_vector_trans == NULL) {
                                    int process_image(float chi_squared,
                                                                                                                    image ptr input,
                                                                                                                                                         matrix_ptr mean,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 return(status);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              return(status);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  return(status);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               return(status);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   if (product1 == NULL) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                norm_vector_trans,
spectral_vector,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            struct timeval before, after;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              status = 0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    status = 0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           int send_val, time, status;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      float smallest, mh dist;
                                                                                                                                                                                                                                                                                                                                                                                                                                       matrix_ptr norm_vector,
                                                                                                                                                                                                                                                                                                                                                                                               /* local variables */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          product1,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         product2;
```

```
/* free all the allocated memory. Order is VERY IMPORTANT: !!!!!!!! */
                                                                                                                                                                                                                                                                                                                                             printf("This pixel was assigned to the background class.\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         free matrix(norm_vector_trans->array,0,norm_vector_trans->num_rows-1,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           if((percent_done > stage) && (percent_done < stage+(2*row_step)))(</pre>
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        (float) (input->num_rows * input->num_cols) );
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    0, norm vector trans->num_cols-1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            AVS_VALUE | AVS_MINVAL | AVS_MAXVAL, percent_classified,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           free_matrix(spectral_vector->array,0, spectral_vector->num_rows-1,
                                          printf("It was assigned to class %d.\n", smallest index);
                                                                                                                                                                                                               printf("%f ",mean->array[smallest_index-1][x]);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 0, spectral_vector->num_cols-1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        /\star report the percentage of the image that is classified \star/
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               0, norm_vector->num_cols-1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         free_matrix(norm_vector->array, 0, norm_vector->num_rows-1,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              percent_classified = 100.0 * ( (float) num_classified /
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      AVSmodule_status("percent complete", send_val);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    0, productl->num_cols-1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     0, product2->num_cols-1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          free matrix (product1->array, 0, product1->num rows-1,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       free_matrix(product2->array, 0, product2->num_rows-1,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            printf("percent complete %d\n", send val);
                                                                                    printf("This class' mean vector is:\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         AVSmodify_float_parameter("Percent classified:",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 percent_done=(float)row/(float)input->num_rows;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            percent_classified);
                                                                                                                                                                        for (x = 0; x < mean->num_cols-1; x++)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  send val = (int) (100.0 * stage);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       /* report the level of completion */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      num_classified += 1;
if (smallest < chi_squared) {</pre>
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      free(norm_vector_trans);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      /* end of col loop */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    } /* end of row loop */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            free(spectral_vector);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             stage += .10;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               free (norm_vector);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   if (assigned == 1)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             free (product1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                    printf("\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              printf("\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          free(psi);
                                                                                                                                                                                                                                                                                                   else{
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         #endif
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 norm_vector_trans->array[band][0]=norm_vector->array[0][band];
                                                                                                                                                                                                                                                                                                                                                                                                                                                                        norm_vector->array[0][band] = spectral_vector->array[0][band]
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              - mean->array[class_num][band];
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            /* move inv_vc[class_num] into structure for mult_matrices */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      #ifdef HIGHPROCESS_DEBUG /* debug code - echo the classification results */
                                                                                                                                                                                                                                                                                           for(class_num = 0; class_num < inv_vc->num_classes; class_num++)(
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   /* account for the ln of the determinant of each class */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          classified->array[row][col] = smallest_index;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 /* classify the pixel, zero is background */
smallest_index = class_num+1;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        mult_matrices(product1, norm_vector_trans, product2);
                                                                                                                                                                                                                                                                                                                                                                                /* normalize the pixel with respect to each class */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     printf("This value must be less than %f to be classified.\n",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              printf("The smallest Mahalanobis distance = %f\n", smallest);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       printf("\nProcessing spectral vector [%d][%d]\n",row,col);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             mh_dist += inv_vc->nlog_determinant[class_num];
                                                                                                                                                                                                                                                                                                                                                                                                                          for(band=0; band < input->num_bands; band++)(
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           printf("%f ", spectral_vector->array[0][x]);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             mult_matrices(norm_vector, psi, productl);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              /* see if this mh_dist is the smallest */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 for(x = 0; x < spectral_vector->num_cols; x++)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  psi->array=inv_vc->array[class_num];
psi->num_rows=inv_vc->num_rows;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               if (smallest < chi squared) (</pre>
if( (interface_skip_zeros) && (magnitude == 0) ) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       /* calculate (x-u)*psi*(x-u)^T */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  mh_dist = product2->array[0][0];
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   psi->num_cols=inv_vc->num_cols;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              smallest = mh dist;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     /* end of class_num loop */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        /* this is the mh dist */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    assigned = 1;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    if(mh_dist < smallest)(</pre>
                                                                                                                                                                                                                                                         /* step through each class */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      chi_squared);
                                          smallest = HUGEMHD;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      /* end else loop */
                                                                                smallest index=0;
                                                                                                                              assigned = 0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            printf("\n");
                                                                                                                                                                                                               else{
```

g 31 01:16:30 1995 PAGE 16		
Last Updated: Thu Aug 31 01:16:30 1995		Filesize: 25.48 kbytes
$\left rac{PAGE}{I5} ight $ Printed: Thu Sep. 7 09:00:22 1995	<pre>free (product2); return(1): /* we're done, let's jam */</pre>	Filename: AVS_gml.c

Source code for the nPDF Projection and nPDF Classification AVS modules

```
"corner 1 and corner 4", "corner 1 and corner 2) corner 1 and corner 3) corner 1 a
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       nd corner 4!corner 2 and corner 3!corner 2 and corner 4!corner 3 and corner 4",
                                                                                                                                                                                                                                                                                                                   in_port = AVScreate_input_port( "Input Image", "field 2D uniform byte",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        param=AVSadd_parameter("Elapsed time (sec):","integer",0,0,INT_UNBOUND)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  param=AVSadd_parameter("Auto-generate nPDF plot", "boolean", 0, 0, 0);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  param = AVSadd_parameter("Scale factor", "integer", 512, 256, 2048);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        /* create a widget to generate the nPDF plot */
param=AVSadd_parameter("Generate nPDF plot", "oneshot", 0, 0, 0);
AVSadd_parameter_prop(param, "width", "integer", 4);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  "nPDF projection parameters", "", "");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        "Select hyper-cube corners:", "", "");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 /\star create an input window for the value of the scale factor \star/
                                                                                                                                                                                                 AVSset_module_name("nPDF Projection", MODULE_FILTER);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       AVSadd_parameter_prop(param, "width", "integer", 4);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      AVSadd_parameter_prop(param, "width", "integer", 4);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 AVSadd_parameter_prop(param, "width", "integer", 4);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          AVSadd_parameter_prop(param, "width", "integer", 2);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              param = AVSadd_parameter("corner_choice", "choice",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         AVSadd_parameter_prop(param, "width", "integer",4);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        AVSadd parameter prop(param, "width", "integer", 2);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                out_port = AVScreate_output_port( "Output Image",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   /* create an output window to display elapsed time */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                param = AVSadd_parameter("title", "string",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      AVSconnect_widget(param, "typein_integer");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             param = AVSadd_parameter("head", "string",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    AVSconnect_widget(param, "radio_buttons");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             AVSconnect widget (param, "typein integer");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             /* create a widget to permit autogeneration */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        "field 2D uniform float" );
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               AVSconnect_widget(param, "toggle");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         /* set up the input windows and buttons */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               AVSconnect_widget(param, "text");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         AVSconnect widget (param, "text");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            /* add a title to the radio buttons */
                                                                                                                                                         /* set the module name and type */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      /* create the radio buttons */
int param;
int in_port, out_port;
                                                                                                                                                                                                                                                                                                                                                               REQUIRED );
                                                                                                                                                                                                                                                                                                                                                                                                                                           /* create the output port */
                                                                                                                                                                                                                                                                                  /* create the input port */
                                                                         int npdf compute();
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     /* free the output data */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    (":")
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  int range, int num_bands,int num_bits,int scale);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             COORDINATE calc_distance(int *spectral_vector,int corner1,int corner2,
                                                                                                                                                                                                                                          of the hypercube from which the distance measures are made as well as
                                                                                                                                                             SUMMARY: This AVS_module performs the nPDF transformation on a given
                                                                                                                                                                                                 input image. In addition, it allows the user to specify the corners
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      /\star this structure is used to reference the output height field \star/
                                                                                                                                                                                                                                                                              the scale factor for the resulting nPDF plot.
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    AVSmodule_from_desc (AVS_npdf);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           unsigned long **array;
                                    AUTHOR: Nessmiller, Steven W.
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                #include <avs/avs_data.h>
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           int AVS_npdf();
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     #include <sys/types.h>
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   #include <avs/field.h>
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             #include <sys/time.h>
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            #include <avs/flow.h>
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           int num_cols;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   int num rows;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  #include <avs/avs.h>
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            #include "memutil.h"
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              #include <liimits.h>
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    #include <stdlib.h>
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        #include <stddef.h>
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            int dist1;
int dist2;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 #include <stdio.h>
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              #define DIST_DEBUG
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      #include <time.h>
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       #define MAXSTR 80
                                                                         10 Feb 95
                                                                                                                                                                                                                                                                                                                                                                                                                                               #include <math.h>
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        typedef struct(
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         #define DEBUG
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         COORDINATE;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                )MAT STRUCT;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     AVS_npdf()
                                                                                DATE:
```

A-30

typedef struct{

/* Prototypes */

```
AVSinit_modules ()
```

Filename: AVS npdf.c

Filesize: 11.48 kbytes

```
/\star set up storage for the spectral vector and the height field array \star/
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    point = calc_distance(spectral_vector, corner1, corner2, range,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                if((percent_done > stage)&&(percent_done < stage+(2*row_step))){</pre>
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   printf("Immediately prior to entering the image processing loop\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              for (band_index=0; band_index < num_bands; band_index ++)
                                                                                                                                                                                                                                                                                                                                                                                                                                                          AVS_VALUE | AVS_MINVAL | AVS_MAXVAL,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              height_field.array[point.dist1][point.dist2]+=1;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             /* zero out the height field array */
for (row=0; row < height_field.num_rows; row++)
for (col=0; col < height_field.num_cols; col++)
                                                                                                                                                                                                                                                                                                                                                                                               /\star clear out the elapsed time from the last run \star/
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            *(I2DV(input_image, col,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             height_field.array = lmatrix(0, scale, 0, scale);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          /\star Do the nPDF transformation on the entire image \star/
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   num_bands, num_bits, scale);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       range = (int)pow(2.0, (double)num_bits) - 1;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          spectral_vector[band_index]
                                                                                                                                                                                                                                                                                                                                                                                                                                 AVSmodify_parameter("Elapsed time (sec):",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              spectral_vector = ivector(0,num_bands-1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               for (col=0; col < num_cols; col++) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 /* set up some stuff that we'll need */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         height_field.array[row][col]=0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    percent_done=(float)row/num_rows;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   for (row=0; row < num_rows; row++) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         height_field.num_cols = scale+1;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        height_field.num_rows = scale+1;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         num_bands = input_image->veclen;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                num_rows = MAXY(input_image);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             num cols = MAXX(input_image);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         gettimeofday(&before,NULL);
                                                                                      corner1=2;
                                                                                                                                                                                                                                              corner1=3;
                                                                                                                                                                                                                                                                            corner2=4;
                                                                                                                     corner2=4;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               row_step = 1.0/num_rows;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            } /* end col loop */
                                                                                                                                                    break;
                                                                                                                                                                                                                                                                                                           break;
  break;
                                                                                                                                                                                                                  case 6:
                                                                case 5:
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           num bits = 8;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       stage = 0.10;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    #ifdef DEBUG
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               #endif
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            AVSmodify_parameter( "Generate nPDF plot", AVS_VALUE, 0, 0, 0);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     /* This is the pixel
/* This is the output height field */
/* and its dimensions
*/
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    corner = AVSchoice_number("corner_choice",corner_choice);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  AVSmark_output_unchanged( "Output Image" );
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        int corner, corner1, corner2, send_val, elapsed_time;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                /* and its dimensions
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        int range, num rows, num cols, num bands, num bits; struct timeval before, after;
                                                                                                                                                                                                               AVSfield float **output image,
/* AVSautofree_output(out_port); */
                                                          /\star set the function to create the output \star/
                                                                                                                                                                                   int npdf_compute(AVSfield_char *input_image,
                                                                                            AVSset_compute_proc(npdf_compute);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        /* decipher the corner choice */
                                                                                                                                                                                                                                                                                                           char *corner_choice,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 float percent_done, row_step, stage;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     int *spectral_vector; /* ;
MAT_STRUCT height_field; /* ;
int dims[2]; /* ;
register int row, col, band_index;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             corner1=1;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 corner1=1;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           corner2=2;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                corner2=3;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      corner1=1;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  corner2=4;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          corner1=2;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         corner2=3;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              /* check if run time */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          break;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            break;
                                                                                                                                                                                                                                                                                                                                                                                               int auto_run,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                break;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          if( run || auto_run )
                                                                                                                                                                                                                                                                            char *title,
                                                                                                                                                                                                                                                char *head,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    return( 1 );
                                                                                                                                                                                                                                                                                                                                          int scale,
                                                                                                                                                                                                                                                                                                                                                                      int time,
                                                                                                                                                                                                                                                                                                                                                                                                                              int run)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               switch (corner) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 case 1:
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  case 2:
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       case 3:
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              case 4:
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         local variables */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      COORDINATE point;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      else {
```

Filename: AVS npdf.c

```
/* we have the two distance measures so now do the nPDF calculations */
                                                                temp2 += pow(( double )(spectral_vector[i]*a[i][corner2-1]),2.0)+
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        temp1 += pow(( double )(spectral_vector[i]*a[i][corner1-1]),2.0)+
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  #ifdef DIST_DEBUG /* Debug code - echo distance values to maintain sanity */
printf("npdf dist1 = %d and npdf dist2 = %d\n",point.dist1,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      /* this matrix holds the coefficients that "turn" the various vector
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         selected corners of the hypercube. Note that the a and b values are
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             the user selected corner value. The matrix coefficients are defined
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             complements and that the column number is essentially one less than
OUTPUTS the two nPDF coordinates in the coordinate structure named
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   templ = ( double )scale * dist1 / (pow(2.0, ( double )num bits)*
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         components on or off to calculate the distances from the user
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           temp2 = (double)scale * dist2 / (pow(2.0, (double)num_bits)*
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                (pow(( double )(range-spectral_vector[i]),2.0)*
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            (pow(( double )(range-spectral_vector[i]),2.0)*
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           COORDINATE calc_distance(int *spectral_vector,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      pow(( double)num bands, 0.5));
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              pow ((double) num bands, 0.5));
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               (1.0-a[i][corner1-1]));
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       (1.0-a[i][corner2-1]));
                                                                                                                                                                                                                                                                            int num_bands,
int num_bits,
int scale)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        for (i =0; i < num_bands; i++) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          point.dist1 = (int)(temp1+0.5);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  point.dist2 = (int) (temp2+0.5);
                                                                                                                                                                                                              int corner2,
                                                                                                                                                                              int cornerl,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              temp1, temp2;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 distl, dist2;
                                                                                                                                                                                                                                               int range,
                                                                                                                                                                                                                                                                                                                                                                                                                       point;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        dist1 = sqrt(temp1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           dist2 = sqrt(temp2);
                                                                                                                                                                                                                                                                                                                                                                                                                             COORDINATE
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    temp1=0.0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       temp2=0.0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              double
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 double
                                      point
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              ***********************
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      INPUTS a num_bands dimensional pixel from the image to be transformed
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     This function calculates the two distance measurements from the user
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            I2D(*output image, col, row) = height_field.array[row][col];
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             ( AVSdata_alloc( "field 2D uniform scalar float", dims ));
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               *output_image = ( AVSfield_float * )
( AVSdata_alloc( "field_2D uniform scalar float", dims ));
                                                                                                                                                                                                                                                                                                                                                                                                                             elapsed_time, elapsed_time, elapsed_time);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 printf("All pixels processed in %d (sec).\n", elapsed_time);
                                                                                                                                                                                                                                                                                                                                                                                AVS_VALUE | AVS_MINVAL | AVS_MAXVAL,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              AVSmodule_status("percent complete", send_val);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        free_ivector(spectral_vector,0,num_bands-1);
free_lmatrix(height_field.array,0,scale,0,scale);
                                   printf("percent complete %d\n", send val);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 AVSfield_free( (AVSfield *) *output_image );
                                                                                                                                                                                                                                                                                                                      elapsed_time=(int)(after.tv_sec-before.tv_sec);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       /* copy the height field to the output port */
                                                                                                                                                                                                                                                                                                                                                         AVSmodify_parameter("Elapsed time (sec):",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           for (col=0; col < scale + 1; col++) (
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         /* set up storage for the output image */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                *output_image = ( AVSfield_float * )
   send_val = (int)(100.0 * stage);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           for (row=0; row < scale + 1; row++) (
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        /* free all the allocated memory */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     defined corners of the hypercube.
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                if ( *output image == NULL ) (
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    printf("Field allocated\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    printf("Field written\n");
                                                                                                                                                                                                                                                                                     gettimeofday(&after,NULL);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            dims[0] = dims[1] = scale;
                                                                                                       stage += .10;
                                                                                                                                                                                                              } /* end row loop */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  /* return success */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  function calc distance
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          } /* end of main */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      return(1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 #ifdef DEBUG
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                #ifdef DEBUG
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   #ifdef DEBUG
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     #end1f
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    #endif
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       #endif
```

Filename: AVS npdf.c

```
printf("The nPDF height field array was successfully written to disk.\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 printf("Please enter the name for the nPDF height field (.hf) array: ");
                                                                                                                                                                                                                                                              by the algorithm to a user defined disk file. Function will happily cream any disk file with the same name as the user inputs.
                                                                                                                                                                                                                                                                                                                                                                                                    this function writes the nPDF height field matrix as determined
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             for(row=0; row < height_field.num_rows; row++) {
  for (col=0; col < height_field.num_cols; col++) {
    fprintf(out_file,"%7d",height_field.array[row][col]);</pre>
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             fflush(stdin): /* clear stdin befor the character read */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  void write_output(MAT_STRUCT height_field)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 out_file = fopen(response, "w");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               fprintf(out_file,"\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   /* rewind(out_file); */
point.dist2);
                                                                                                                                                                } /* end of calc_distance */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      fclose(out_file);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      gets (response);
                                                                                                 return(point);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     register int row, col;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   char response[MAXSTR];
                                                                                                                                                                                                                                                                                                                                                                     function write_output
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   FILE *out_file;
                                 #endif
```

Filename: AVS_npdf.c

```
This program performs image classification by applying the nPDF transformation
                                                                                                                                                                                                                                                                                                                                                                                                 and utilizing a previously determined LUT. The nPDF distance measurements are
                                                                                                                                                                                                                                                                                                                                                                                                                                                           calculated for each pixel in the original image and these two values are used
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     to index the LUT. If the distances reference a target class in the LUT, the
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         pixel's resulting distances place it outside of any class, it is assigned a value of zero. The user must inform the program of the corners of the hypercube utilized to make the LUT as this information is otherwise
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          pixel in the output image is assigned that class' numerical value. If the
TITLE: npdf_classification.c
                                               AUTHOR: Nessmiller, Steven W.
                                                                                                              3 March 1995
                                                                                                                                                                                                                                  SUMMARY:
                                                                                                                    DATE:
```

```
22 July 95 added skip zero vector support
                        22 May 95 added LUT support
REVISIONS:
```

unavailable

```
/\star this structure is used to reference the classification map \star/
                                                                                                                                                                                                      /* layered debug definitions */
                                                                                                                                                                                                                                                /* #define DIST DEBUG */
                                                                                                                      #include <avs/field.h>
                                                                                #include <sys/time.h>
                                                                                                                                         #include <avs/flow.h>
                                                                                                 #include <avs/avs.h>
                                                                                                                                                              #include "memutil.h"
                                                                                                                                                                                                                                                                                                                                                                                                                                                                             int **array;
                                      #include <stddef.h>
                    #include <stdlib.h>
                                                           #include <stdio.h>
                                                                                                                                                                                                                                                                                                                                                 int distl;
                                                                                                                                                                                                                                                                                                                                                                        int dist2;
                                                                                                                                                                                                                                                                                        #define MAXSTR 80
#include <math.h>
                                                                                                                                                                                                                                                                                                                                typedef struct{
                                                                                                                                                                                                                                                                                                                                                                                                                                                          struct (
                                                                                                                                                                                                                           #define DEBUG
                                                                                                                                                                                                                                                                                                                                                                                             COORDINATE;
                                                                                                                                                                                                                                                                                                                                                                                                                                                      typedef
                                         A-34
```

```
int range, int num_bands, int num_bits, int scale);
                                                                                                                                                                                                                            COORDINATE calc_distance(int *spectral_vector,int corner1,int corner2,
int num_rows;
                                         int num cols;
                                                                           CLASS MAP STRUCT;
                                                                                                                                                                                          /* Prototypes */
```

```
param = AVSadd_parameter("title", "string", "Select hyper-cube corners:"
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      /* create the image input port - this one will be leftmost */
in_port = AVscreate_input_port( "Input Image", "field 2D uniform byte",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          LUT_port = AVScreate_input_port("LUT Image","field 2D uniform float",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            "nPDF classification parameters", "", "");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       AVSset_module_name("nPDF Classification", MODULE_FILTER);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       /* create the LUT input port - this one will be rightmost */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    AVSadd_parameter_prop(param,"width","integer",4);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                AVSadd_parameter_prop(param,"width","integer",4);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                out port = AVScreate output port( "Output Image",
                                                                                                                      AVSmodule_from_desc(AVS_npdf_classification);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            REQUIRED );
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      REQUIRED);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     param = AVSadd_parameter("head", "string",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           "field 2D uniform float" );
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              /\star set up the input windows and buttons \star/
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   AVSconnect_widget(param, "text");
                                                                                                                                                                                                                                                                                                                                                                                      int in_port, out_port, LUT_port;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  /* add a title to the radio buttons */
                                                                          int AVS_npdf_classification();
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                /* set the module name and type */
                                                                                                                                                                                                                                                                                                                                                                                                                             int npdf_compute_class();
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        /* create the output port */
                                                                                                                                                                                                                                                    AVS_npdf_classification()
                                                                                                                                                                                                                                                                                                                                          int param;
AVSinit_modules ()
```

```
"corner 1 and corner 4", "corner 1 and corner 2; corner 1 and corner 3; corner 1
                                                                                                                          and corner 4!corner 2 and corner 3!corner 2 and corner 4!corner 3 and corner 4
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    param = AVSadd parameter("Scale factor:", "integer",512, 256, 2048);
AVSadd_parameter_prop(param, "width", "integer",2);
                                                                                                                                                                                                                                                                                                                                                                                                                                                /\star create an input window for the value of the scale factor \star/
param = AVSadd_parameter("corner_choice", "choice",
                                                                                                                                                                                                                                                           AVSadd_parameter_prop(param, "width", "integer",4);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          AVSconnect_widget(param, "typein_integer");
                                                                                                                                                                                                                                                                                                                           AVSconnect_widget(param, "radio_buttons");
```

 $/\star$ create the radio butons to input the values of the corners $^{\star}/$

AVSconnect widget (param, "text");

```
param = AVSadd float parameter("Percent classified:", 0.0, 0.0, 100.0);
                                                                                                                                         AVSadd_parameter_prop(param, "width", "integer", 2);
/* create a widget to display the percent classified */
                                                                                                                                                                                                                 AVSconnect widget (param, "typein real");
```

/* create an output window to display elapsed time */

```
param=AVSadd_parameter("Elapsed time (sec):","integer",0,0,1NT_UNBOUND);
AVSadd_parameter_prop(param,"width","integer",2);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 AVSmodify_parameter( "Classify image", AVS_VALUE, 0, 0, 0);
                                                                                                                                                                                                                                                                                                                                                                                         param=AVSadd_parameter("Auto-classify image", "boolean", 0, 0, 0);
                                                                                                                                                                                                param=AVSadd_parameter("Skip zero vectors", "boolean", 0, 0, 0);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        int corner2, target_class, send_val, scale, magnitude, num_classified;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      param=AVSadd_parameter("Classify image", "oneshot", 0, 0, 0);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     int range, num rows, num cols, num bands, num bits, corner, corner1;
                                                                                                                                                                                                                                      AVSadd_parameter_prop(param, "width", "integer", 4);
                                                                                                                                                                                                                                                                                                                                                                                                                            AVSadd_parameter_prop(param, "width", "integer", 4);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      AVSadd_parameter_prop(param, "width", "integer", 4);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 AVSmark_output_unchanged("Output Image");
return(1);
                                                                                                                                                             /\star create a widget to allow zero vectors to be skipped \star/
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        float percent_done, percent_classified, row_step, stage;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     /* This is the class map
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         float *interface_percent_classified,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        /* and its dimensions
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               /* This is the pixel
                                                                                AVSconnect_widget(param,"typein_integer");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      int npdf_compute_class(AVSfield_char *input_image,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         AVSset_compute_proc(npdf_compute_class);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                create a widget to generate the nPDF plot */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   AVSfield_float **output_image,
                                                                                                                                                                                                                                                                                                                                                      /* create a widget to permit autogeneration */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                      AVSconnect_widget(param, "toggle");
                                                                                                                                                                                                                                                                             AVSconnect_widget(param, "toggle");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   /* set the function to create the output */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            AVSfield float *lut image,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        int skip_zero_vectors,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         AVSautofree output (out_port);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               char *corner_choice,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  int interface_scale,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               register int row, col, band index;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        /* check if run time */
if( run || auto_run )
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              int auto_run,
int run)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            char *title,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               struct timeval before, after;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         char *head,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  CLASS_MAP_STRUCT class_map;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   /* free the output data */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            /* local variables */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               int *spectral_vector;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 COORDINATE point;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              else (
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                *
```

```
/st set up storage for the spectral vector and the class map st/
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               corner = AVScholce number ("corner_choice", corner_choice);
                                                                                                                                                                                                                                                                                     AVS_VALUE | AVS_MINVAL | AVS_MAXVAL,
                                                                                                                                                                                                                                                                                                                                                                                         AVS_VALUE | AVS_MINVAL | AVS_MAXVAL,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   /\star the class map is the same size as the input image ^{\star}/
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        class_map.array = imatrix(0,num_rows-1,0,num_cols-1);
class_map.num_rows = num_rows;
/* set up some variables that we'll need */
                                                                                                                                                          range = (int)pow(2.0, (double)num bits) - 1;
                                                                                                                                                                                                                                                             AVSmodify_parameter("Elapsed time (sec):",
                                                                                                                                                                                                                                                                                                                                                                                                                       scale, scale, scale);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   spectral_vector = ivector(0,num_bands-1);
                                                                                                                                                                                                                                                                                                                                                               AVSmodify_parameter("Scale factor:",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                       corner choice */
                                                                                                        num_bands = input_image->veclen;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              class_map.num_cols = num_cols;
                            num_rows = MAXY(input_image);
                                                                              num cols = MAXX(input image);
                                                                                                                                                                                                                                      /* update the interface */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              corner1=1;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      corner2=4;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               corner1=2;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       corner1=1;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 corner2=2;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           corner1=1;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     corner2=3;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         corner2=3;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     corner1=2;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  corner2=4;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           corner1=3;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     corner2=4;
                                                 row_step = 1.0/num_rows;
                                                                                                                                                                                      scale = MAXX(lut_image);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            break;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    break;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          break;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         break;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  break;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                break;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                         /* decipher the
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      case 3:
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          case 4:
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              case 5:
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 case 6:
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     switch (corner) (
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             case 1:
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                case 2:
                                                                                                                                  num bits = 8;
```

Filename: npdf classification.c

```
INPUTS a num_bands dimensional pixel from the image to be transformed
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            This function calculates the two distance measurements from the user
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          *output_image = ( AVSfield_float * )
( AVSdata_alloc( "field 2D uniform scalar float", dims ));
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          OUTPUTS the two nPDF coordinates in the coordinate structure named
                                                                                                                                                                                                                                                                                                                                                                                                       ( AVSdata alloc( "field 2D uniform scalar float", dims ));
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       I2D(*output image, col, row) = class map.array[row][col];
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  ( dims[ 1 ] != MAXY( *output_image ) ) ) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       free_ivector(spectral_vector,0,num_bands-1);
free_imatrix(class_map.array, 0, class_map.num_rows-1,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         /\star copy the classification map to the output port \star/
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                else if ( ( dims[ 0 ] != MAXX( *output_image ) ) ||
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    for (col=0; col < class_map.num_cols; col++) (
Last Updated: Thu Aug 31 01:16:29 1995
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    AVSfield_free( (AVSfield *) *output_image );
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              for (row=0; row < class_map.num_rows; row++) {
                                                                                                                                                                                                                 /\star set up storage for the output image \star/
                                                                                                                                                                                                                                                                                                                                                                     *output image = ( AVSfield_float * )
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                0, class_map.num_cols-1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          COORDINATE calc_distance(int *spectral_vector,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  /* free all the allocated memory ^{\star}/
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  defined corners of the hypercube.
                                                                                                                                                                                                                                                                                                                               if ( *output image == NULL ) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           int num bands,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 int num bits,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                printf("Field allocated\n" );
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   int corner2,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             int corner1,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         printf("Field written\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        int range,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           /* return success */
                                                                                                                                                                                                                                                       dims[0] = num_cols;
                                                                                                                                                                                                                                                                                         dims[1] = num_rows;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          function calc_distance
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      } /* end of main */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 return(1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              #1fdef DEBUG
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          #ifdef DEBUG
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      #endif
                                                                                                                                         #endif
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   #endif
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       target_class = I2D(lut_image, point.dist2, point.dist1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    range, num_bands, num_bits, scale);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         percent_done=(float)row/(float)num_rows;
if((percent_done > stage) && (percent_done < stage+(2*row_step))){</pre>
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              point = calc_distance(spectral_vector,corner1,corner2,
                                                                                                                                                                           printf("Immediately prior to entering the image processing loop\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                *(I2DV(input_image, col, row)+band_index);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        for (band_index=0; band_index < num_bands; band_index ++) {</pre>
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                if ( (skip_zero_vectors == 1) && (magnitude == 0) )
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           percent_classified, percent_classified,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      magnitude += spectral_vector[band_index];
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        AVS VALUE | AVS MINVAL | AVS MAXVAL,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     AVS_VALUE | AVS_MINVAL | AVS_MAXVAL,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              time=(int)(after.tv_sec-before.tv_sec);
percent_classified = 100.0 * ( (float)num_classified /
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   AVSmodule_status("percent complete", send_val);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       (float) (num_rows * num_cols) );
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               class_map.array[row][col] = target_class;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              printf("percent complete %d\n", send val);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      /* report elapsed time and percent classified */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               AVSmodify_float_parameter("Percent classified:",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              spectral_vector[band_index] =
                                                                                                                                                                                                                                                                                         /* Do the nPDF classification on the entire image */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               AVSmodify_parameter("Elapsed time (sec):",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                for (col=0; col < num_cols; col++) (
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        send_val = (int)(100.0 * stage);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          /* report the level of completion */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 percent classified);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       time, time, time);
                                                                                                                                                                                                                                                                                                                                                                                                                                             for (row=0; row < num_rows; row++) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    num_classified += 1;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      target_class = 0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     if (target_class != 0)
                                                                                                                                                                                                                                                                                                                               gettimeofday(&before,NULL);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         gettimeofday(&after,NULL);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     magnitude = 0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         stage += .10;
                                                                                                                                                                                                                                                                                                                                                                     num_classified = 0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            else{
                                                                                                                                                                                                                                                                                                                                                                                                           stage = 0.10;
                                                                                                                                         #ifdef DEBUG
                                                                                                                                                                                                                 #endif
```

printf("All pixels classified in %d (sec). \n", time);

#ifdef DEBUG

int scale)

point;

COORDINATE

```
#ifdef DIST_DEBUG /* Debug code - echo distance values to maintain sanity */
printf("npdf distl = %d and npdf dist2 = %d\n",point.dist1, point.dist2);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            temp1 += pow(( double )(spectral_vector[i]*a[i][corner1-1]),2.0)+
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              temp2 += pow(( double )(spectral_vector[i]*a[i][corner2-1]),2.0)+
                                                                                                                                                                                          selected corners of the hypercube. Note that the a and b values are
                                                                                                                                   /* this matrix holds the coefficients that "turn" the various vector
                                                                                                                                                                                                                                                 the user selected corner value. The matrix coefficients are defined
                                                                                                                                                                                                                     complements and that the column number is essentially one less than
                                                                                                                                                               components on or off to calculate the distances from the user
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         (pow(( double ) (range-spectral_vector[i]), 2.0) *
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      (pow(( double ) (range-spectral_vector[i]), 2.0) *
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  temp2 = (double) scale * dist2 / (pow(2.0, (double) num bits) *
                                                                                                                                                                                                                                                                                                                         (1.0-a[i][corner1-1]));
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    (1.0-a[i][corner2-1]));
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           pow((double)num_bands,0.5));
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   for (i =0; i < num_bands; i++) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      point.dist2 = (int) (temp2+0.5);
  i;
templ,temp2;
                                                    distl, dist2;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 dist1 = sqrt(temp1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             dist2 = sqrt(temp2);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       } /* end of calc_distance */
                                                                                                                                                                                                                                                                         as follows: */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     return(point);
                                                                                                                                                                                                                                                                                                                              static int
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   temp1=0.0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            temp2=0.0;
int
double
                                                      double
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               #endif
```

Source code for the Make ARTMAP and Fuzzy ARTMAP Classification AVS modules and supporting ART and fuzzy set theory algorithms

/* initialize the modules */

```
AVS FUZZY ARTMAP (1995) Rochester Institute of Technology
                                                                                                                                                                                                                                               ** Original fuzzy ARTMAP code written by Ah-Hwee Tan at Boston University **
                                                                                                                                                                                                                                                                                                                                                                                                                                    This software tool creates a fuzzy artmap neural network from a training image. It then writes the network data to a disk file that can be utilized by the classification module.
                                                                                                                                                                                                                                                                                                                                       ** ported to ANSI C and the AVS environment by Steven W. Nessmiller **
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            12 May 1995 - implemented reading of training set via the IPI library
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   29 March 1995 - ANSI C port
                                                                                                                                                  File Name: AVS_makenet.c
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           7 April 1995 - AVS port
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              Revision history:
```

```
#include "/cis/src/local/avs/src/IPI/avs types.h"
                                                                                                                                                                                                                                                      #include <avs/avs data.h>
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        #define INTERFACE_DEBUG
                                                                                                                                                                                                   #include <avs/field.h>
                                                                                                                                                  #include <sys/types.h>
                         #include <sys/types.h>
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 #define TRAINING DEBUG
                                                                                               #include <sys/time.h>
                                                                                                                        #include <sys/file.h>
                                                                                                                                                                                                                            #include <avs/flow.h>
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 #define PROCESS_DEBUG
                                                                                                                                                                         #include <avs/avs.h>
                                                                                                                                                                                                                                                                                                                                                       #include "memutil.h"
                                                #include <stdlib.h>
                                                                                                                                                                                                                                                                                                                              #include "struct.h"
                                                                                                                                                                                                                                                                             #include <IPIlib.h>
                                                                                                                                                                                                                                                                                                                                                                                                        finclude "ptypes.h"
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           #define INPUT_DEBUG
#include <stdio.h>
                                                                          #include <math.h>
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     #define ART_DEBUG
                                                                                                                                                                                                                                                                                                                                                                              #include "idef.h"
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     #define MAXSTR 80
                                                                                                                                                                                                                                                                                                                                                                                                                                                      #define DEBUG
```

```
param=AVSadd_parameter("Parameter file (*.par):","string",cwd,0,".par")
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     param=AVSadd_parameter("Network file (*.net):","string",cwd,0,".net");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     in_port = AVScreate_input_port("Input Training Set", Training_Field,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          param=AVSadd_parameter("title","string","Fuzzy ARTMAP Parameters",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                param = AVSadd_parameter("View all file types", "boolean",0,0,1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         param=AVSadd_float_parameter("rho for ARTa", 0.90, 0.1, 1.0);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              AVSset_module_name("Make fuzzy ARTMAP", MODULE_FILTER);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          AVSadd_parameter_prop(param, "width", "integer",4);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   AVSadd_parameter_prop(param, "width","integer",4);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   AVSadd parameter prop(param, "width", "integer", 4);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       AVSadd_parameter_prop(param,"width","integer",4);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               REQUIRED );
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               /\star create the input port for the training data \star/
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     /\star create a widget for the parameter filename ^{\star}/
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               AVSconnect_widget(param, "typein_real");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              /* create a widget for the network filename */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                /* create a widget to set min rho for ARTb ^{\star}/
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               /* create a widget to set min rho for ARTa */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             AVSconnect_widget(param, "browser");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          AVSconnect_widget(param, "browser");
                                                                                                                      AVSmodule_from_desc(AVS_makenet);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         AVSconnect_widget(param,"text");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    "", "");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             /* allow user to view all file types */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      if( cwd[strlen(cwd)-1] != '/')
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    /* set the title for the window */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    /* set the module name and type */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            strcat(cwd,"/");
                                                                                                                                                                                                                                                                                                                                                                                int compute_makenet();
                                                                                    int AVS_makenet();
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       char cwd[MAXSTR];
                                                                                                                                                                                                                                                     /* interface routine */
                                                                                                                                                                                                                                                                                                                                                                                                                                                             int in_port;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       qetwd (cwd);
                                                                                                                                                                                                                                                                                                                                                                                                                          int param;
AVSinit_modules()
                                                                                                                                                                                                                                                                                            AVS_makenet()
```

param=AVSadd_parameter("Number of training patterns:","integer", 0, 0, param=AVSadd_float_parameter("rho for ARTb", 1.0, 0.1, 1.0); $/\star$ create a widget to display the number of training patterns $^\star/$ AVSadd_parameter_prop(param,"width","integer",2); AVSconnect_widget(param, "typein_real"); INT UNBOUND);

void remap_pixel(parameter_struct_ptr parameter, float *pixel, int flag,

/* function prototypes */

float min, float max);

AVSconnect_widget(param,"typein_integer");

Last Updated: Thu Aug 31 01:16:36 1995

```
MAIN
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   param=AVSadd_parameter("Learning iteration:","integer",0,0,1,INT_UNBOUND);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               param=AVSadd_parameter("Elapsed time (sec):", "integer", 0,0,1NT_UNBOUND)
                                              param=AVSadd_parameter("Number of training classes:","integer", 0, 0,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          param=AVSadd_parameter("ARTa classification nodes:","integer", 0, 0,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   param=AVSadd_parameter("Recast inconsistent cases","boolean",0,0,0);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      param = AVSadd_parameter("Update parameter file", "boolean",0,0,1);
AVSadd_parameter_prop(param, "width", "integer",4);
                                                                                                                                                                                                                                                                                                          /\star create a widget to display the number of bands in the training sets \star/
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  /\star create a widget to display the number of ARTa classification nodes ^\star/
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          param=AVSadd_parameter("Auto-generate network","boolean",0,0,0);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 param=AVSadd_parameter("Generate network", "oneshot", 0, 0, 0);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          param=AVSadd_parameter("Maximum iteration:","integer", 10, 0,
                                                                                                                                                                                                                                                                                                                                                        param=AVSadd_parameter("Number of bands:", "integer", 0, 0,
/\star create a widget to display the number of training classes \star/
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               /\,\star create a widget to display the current learning iteration ^{\star}/
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      create a widget to display the maximum learning iteration ^{\star}/
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      AVSadd_parameter_prop(param, "width", "integer", 4);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             AVSadd_parameter_prop(param, "width", "integer", 4);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    AVSadd_parameter_prop(param, "width", "integer", 4);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      AVSadd_parameter_prop(param,"width","integer",2);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                    AVSadd_parameter_prop(param,"width","integer",2);
                                                                                                                                                     AVSadd_parameter_prop(param,"width","integer",2);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            AVSadd_parameter_prop(param,"width","integer",2);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           AVSadd_parameter_prop(param,"width","integer",2);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            AVSadd_parameter_prop(param,"width","integer",2);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       /\star create a widget to update the parameter file \star/
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         AVSconnect_widget(param, "typein_integer");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    AVSconnect_widget(param, "typein_integer");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          AVSconnect_widget(param,"typein_integer");
                                                                                                                                                                                                   AVSconnect_widget(param, "typein_integer");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              AVSconnect_widget(param, "typein_integer");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               AVSconnect_widget(param,"typein_integer");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            /* create a widget to display the elapsed time */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              create a widget to generate the output file ^{\star}/
                                                                                                           INT UNBOUND);
                                                                                                                                                                                                                                                                                                                                                                                                                INT UNBOUND);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  INT UNBOUND);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                AVSset_compute_proc(compute_makenet);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             INT_UNBOUND);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            AVSconnect_widget(param, "toggle");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         AVSconnect_widget(param, "toggle");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 /* set the function to create the output */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       /* create autogeneration widget */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                /* create a recasting widget */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      *
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              *
```

A-40

if(AVSparameter_changed("View all file types")){
 if (all) { int status, comp_flag, A_winner, B_winner, class_val; int list_row, training_bands, send_val, elapsed_time; /* check for view all parameter filenames */ int learn iter, int interface max_iterations, int time, int num nodes, int interface_update, int interface_recast, int auto_run, int run) int prediction, times_through_training, result; int interface num patterns, int interface_num_classes, int interface_num_bands, char *network_filename, float *interface Arho, float *interface Brho, char *param_filename, register int class, row, band, index, j; static char old_network_filename(80]; float percent done, row step, stage; int compute_makenet(AVSfield *input, char *reset_network_filename = " "; static char old param filename[80]; static int first_time_through = 1; char *reset_param_filename = " "; char *title, parameter_struct_ptr parameter; IPItraining trainchain = NULL; struct timeval before, after; IPItraining trainset = NULL; int all, network_data_ptr network; static int goodpar = 0; netstat_ptr net_status; series_data_ptr series; FILE *input_param_file; static int goodnet = 0; /* local variables */ float min, max, temp; data_struct_ptr data; double *train_vector; FILE *output file; int *length;

Filename: AVS makenet.c

```
/* end if */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         goodnet = 1;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 goodnet = 1;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    } /* end else */
                                                                                                                                                return(1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   if(status != 0) (
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               #ifdef INTERFACE_DEBUG
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               else{
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                #endif
                                                                                                                                                                                                                                                                                                                                                                   *
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 ×
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      parameter=(parameter_struct_ptr)malloc(sizeof(PARAMETER STRUCTURE));
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     printf("ERROR: unable to allocate the parameter structure.\normalfont{\mathsf{n}}");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             printf("AVS Make fuzzy ARIMAP needs a valid parameter file.\n")
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       AVS_VALUE, param_filename, 0, 0);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              AVS_VALUE, network_filename, 0,
                                                                                                                                                                                                                                                                                                                                                                                                                                         AVS VALUE (AVS MAXVAL, "/tmp/", 0, ".par");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            AVS_VALUE|AVS_MAXVAL, "/tmp/", 0, ".net");
                                                                                                                                                                              AVSmodify_parameter("Parameter file (*.par):",
AVSmodify_parameter("Parameter file (*.par):",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              printf( "Setting maxval to .par and .net\n");
                                                                                                                                                                                                                                                                                                                                                                                                    AVSmodify_parameter("Parameter file (*.par):",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      AVSmodify_parameter("Parameter file (*.par):",
                                                                      AVSmodify_parameter("Network file (*.net):",
                                                                                                                                                                                                                                                    AVSmodify_parameter("Network file (*.net):",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                           AVSmodify_parameter("Network file (*.net):",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     AVSmodify_parameter("Network file (*.net):",
                                                                                                       AVS_VALUE|AVS_MAXVAL, "/tmp/",0,"");
                                 AVS_VALUE|AVS_MAXVAL, "/tmp/",0,"");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    goodpar = read_parameters(param_filename, parameter);
                                                                                                                                                                                                                                                                                         AVS_VALUE, network_filename, 0, 0);
                                                                                                                                                                                                               AVS_VALUE, param_filename, 0, 0);
                                                                                                                                         printf( "Setting maxval to null\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     status = strcmp(param_filename, old_param_filename);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     input_param_file = fopen(param_filename, "r+");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           /* display the parameter file to stdout */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 printf("Allocating the parameter file.\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    strcpy(old_param_filename, param_filename);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                status = display_parameters(parameter);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    /* see if the parameter file has changed */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            if(input_param_file == NULL) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  fclose(input_param_file);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       first_time_through = 0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    if (parameter ==NULL) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         if(first time through){
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               return(1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       return(1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           if(status != 0) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             if(goodpar){
                                                                                                                                                                                                                                                                                                                                                         else{
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             /* end if */
```

```
"Network file %s already exists.\n", network_filename);
                                                                                    "Exit", "Paramater file %s is not a valid file.\n",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            /* file already exists, close file and check for overwrite */
printf("ERROR: bad status returned by read_parameters.\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     printf("The selected parameter filename is: %s\n", param_filename);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           printf("The old network filename is: %s\n", old_network_filename);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       printf("The selected network filename is: %s\n",network_filename);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              printf("The old parameter filename is: %s\n", old_param_filename);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      answer = AVSmessage("beta", AVS_Warning, NULL, "Make ARTMAP",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    AVSmodify_float_parameter("rho for ARTa", AVS_VALUE,
                                              AVSmessage ("beta", AVS Warning, NULL, "Make ARTMAP",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            status = strcmp(network_filename, old_network_filename);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    printf("Rho for ARTA reset to %f\n", send_val);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          strcpy(old_network_filename, network_filename);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 send val, 0, 0);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        printf("Network file already exists.\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   printf("Network file does not exist.\n");
                                                                                                                                                                                                                                                                                                                                                                                                           /* check for updated rho value from interface */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            output_file = fopen(network filename, "x+");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      send_val = (int)(temp+0.5))/100.0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     if(strcmp(answer, "Overwrite") != 0){
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    if( AVSparameter_changed("rho for ARTa") ) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         /* see if the network file has changed */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                temp = *interface_Arho * 100.0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         if ( run || auto_run) && (goodnet && goodpar) )
                                                                                                                                      param_filename);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     "Overwrite!Cancel",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     if(output file == NULL){
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              fclose (output_file);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       return(1);
```

else{

```
data->num bands);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         data->num_pixels = 0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  trainset = NULL;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              class += 1;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               #ifdef TRAINING_DEBUG
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   class = 0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           #ifdef DEBUG
                                   #ifdef DEBUG
                                                                                                                                                                                                                                                                                                      #ifdef DEBUG
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            #ifdef DEBUG
                                                                                           #endif
                                                                                                                                                                                                                                                                                                                                                            #endif
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    #endif
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   #endif
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       #endif
AVSmodify_parameter("Generate network", AVS_VALUE, 0, 0, 0);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   printf("Unable to malloc series structure pointer.\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  printf("Unable to malloc status structure pointer.\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     network=(network_data_ptr)malloc(sizeof(NETWORK_DATA_STRUCT));
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               series = (series_data_ptr)malloc(sizeof(SERIES_DATA_STRUCT));
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               printf("Unable to malloc data structure pointer.\n");
                                                                                                                                            printf("Make ARTMAP just entered the compute function.\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              printf("ERROR: unable to allocate the network.\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                        AVS_VALUE | AVS_MINVAL | AVS_MAXVAL,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               AVS_VALUE | AVS_MINVAL | AVS_MAXVAL,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            AVSmodify_parameter("Elapsed time (sec):",
AVS_MINVAL | AVS_MAXVAL,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   AVS_VALUE | AVS_MINVAL | AVS_MAXVAL,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         AVS_VALUE | AVS_MINVAL | AVS_MAXVAL,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 AVS_VALUE | AVS_MINVAL | AVS_MAXVAL,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          net_status = (netstat_ptr)malloc(sizeof(STATUS_STRUCT));
                                                                                                                                                                                                                                                                                           strcpy(old_network_filename, reset_network_filename);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         data = (data_struct_ptr)malloc(sizeof(DATA_STRUCT));
                                                                                                                                                                                                                                                                                                                                                                                                                                        AVSmodify_parameter("Number of training patterns:",
                                                                                                                                                                                                                                                                                                                 strcpy(old_param_filename, reset_param_filename);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 AVSmodify_parameter("Number of training classes:",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      AVSmodify_parameter("ARTa classification nodes:",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              AVSmodify_parameter("Learning iteration:",
                                                                                                                                                                                                                                                                                                                                                                                                             /* clear out parameters from last run */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        AVSmodify_parameter("Number of bands:",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       /* allocate other data structures */
                                                                                                                                                                                                     /* reset the static variables */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             0,0,0
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      0,0,0
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   0,0,0
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       0,0,0
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             0,0,0
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 0,0,0,0
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          (net_status == NULL) {
                                                                                                                                                                                                                                                                                                                                                    first_time_through = 1;
                                                        return(1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                if (network==NULL) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             (series==NULL) (
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              return(1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      return(1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   return(1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  if (data == NULL) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                return(1);
                                                                                                                                                                                                                                   goodpar = 0;
                                                                                                                                                                                                                                                                goodnet = 0;
                           else {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        Ξŧ
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       Ŧ
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\prime^{\star} get number of bands in the training sets and update the interface ^{\star}\prime
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           /\star get the number of training classes and update the interface \star/
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          data->dpt = matrix(0, data->num_pixels-1, 0, data->num_bands-1);
data->label = ivector(0, data->num_pixels-1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       data->num_classes = IPIlength of training chain( trainchain );
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               printf("There are %d classes of data.\n", data->num_classes);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          printf("Number of pixels per class has been calculated.\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   *
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      printf("The number of pixels in class %d is %d.\n",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          printf("Total number of pixels = %d.\n", data->num pixels);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          /* get the pixel list parameters and allocate memory
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          IPInext_on_training_chain( &trainchain, &trainset );
printf("Just executed first next_on_training_chain.\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     length[ class ] = IPIsize_of_training_set(trainset);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  IPInext_on_training_chain( &trainchain, &trainset );
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       printf("Executed next_on_training_chain again.\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          printf("There are %d bands in the training sets.\n",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       IPIget_training_bands(trainchain, &training_bands);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      for(class = 0; class < data->num_classes; class++)(
                                                                                                                                       /\star copy the training data to the pixel list structure \star/
                                                                                                                                                                                                                                                                                   IPIfield_to_training(input,NULL, &trainchain,0);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      /* Get all the training set information */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      data->num_pixels += length[ class ];
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           length = ivector(0, data->num_classes);
printf("All structures allocated.\n");
                                                                                                                                                                                                                                                                                                                                                                                                                           printf("Training field converted.\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      class, length[class]);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       data->num_bands = training_bands;
                                                                                                                                                                                                                                       /* Convert the training field */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          while (trainset != NULL) {
```

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network->rho[ARTa] = parameter->min_arho;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    #ifdef INPUT DEBUG
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     #ifdef DEBUG
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       #ifdef DEBUG
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              #endlf
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               #endif
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         IPIget_training_vector(trainset, row - list_row, train_vector);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  network->num_att[ARTa] = parameter->a_length*(1+parameter->complement);
network->num_att[ARTb] = parameter->b_length*(1+parameter->complement);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      printf("Rho for ARTa from the interface = %f\n", *interface_Arho);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          printf("Rho for ARTb from the interface = %f\n", *interface_Brho);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                for(row = list_row; row < list_row + length[class]; row++)(</pre>
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           for(band = 0; band < data->num_bands; band++) {
    data->dpt[row][band] = (float)train_vector[band];
                                                                                                                                                                                                                                                                                                                                                         IPInext_on_training_chain( &trainchain, &trainset );
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         /* print out the training pixels */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            list_row += length[class];
printf("Class %d successfully read in.\n",class);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 parameter->max_iterations = interface_max_iterations;
                                                                                                                                                                                                                                                                                                                    for(class = 0; class < data->num classes; class++) {
data->frequency = ivector(0, data->num_classes+1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              for(band = 0; band <= data->num_bands; band++) (
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          printf("Training data successfully read in.\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    free_dvector(train_vector,0,data->num_bands-1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             /\star reset any variables that may have changed \star/
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   printf("%d\t", data->array[row][band]);
                                                                                                              /\star read the training data into the data structure \star/
                                                                                                                                                                                               train_vector = dvector(0, data->num_bands-1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            parameter->train_pats = data->num_pixels;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                              printf("Reading in class %d.\n", class);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   parameter->b_length = data->num_classes;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      parameter->min_arho = *interface_Arho;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           parameter->a_length = data->num_bands;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            data->label[row] = class;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       network->num_category[ARTa] = 0;
network->num_category[ARTb] = 0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         } /* end of row loop */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            } /* end band loop */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     } /* end of class loop */
                                                                                                                                                                                                                                                                            trainset = NULL;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      #ifdef TRAINING DEBUG
                                                                                                                                                          list_row = 0;
                                                                                                                                                                                                                                                                                                                                                                                                                                      #ifdef TRAINING DEBUG
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                printf("\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      #ifdef TRAINING DEBUG
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   #endif
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         #endif
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               #endif
```

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```
interface_max_iterations, interface_max_iterations,
                                                                                                                                                                                                                                                                                                                                                                 interface_num_patterns, interface_num_patterns,
                                                                                                                                                                                  \prime \star update interface with number of training pattern information \star \prime
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         printf("rho for ARTa = %f rho for ARTb = %f\n",network->rho[ARTa],
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         interface_num_classes, interface_num_classes,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          interface_num_bands, interface_num_bands,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            printf("Num atributes ARTa = %d Num attributes ARTb = %d.\n",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       printf("Alength = %d Blength = %d.\n", parameter->a_length,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    for (band = 0; band < parameter->a_length; band++)
printf("%1.0f ",data->dpt[row][band]);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       printf("Internal data pointer = %x.\n", data->dpt[0][0]);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  printf("Internal label pointer = %x.\n", data->label[0]);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              network->num_att[ARTa], network->num_att[ARTb]);
printf("Complement coding = %d.\n", comp_flag);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   ", data->dpt[row][band]);
                                                                                                                                                                                                                                                                                                                          AVS_VALUE | AVS_MINVAL | AVS_MAXVAL,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           AVS_VALUE | AVS_MINVAL | AVS_MAXVAL,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           AVS_VALUE | AVS_MINVAL | AVS_MAXVAL,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              AVS_VALUE | AVS_MINVAL | AVS_MAXVAL,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   /* echo the data values and label to maintain sanity ^{\star}/
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          printf("Number of pixels = %d.\n", data->num_pixels);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     interface_max_iterations = parameter->max_iterations;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    printf("Number of bands = %d.\n", data->num_bands);
                                                                                                                                                                                                                                                                       AVSmodify_parameter("Number of training patterns:",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            AVSmodify_parameter("Number of training classes:",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           printf("Internal ARTMAP memory allocated.\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           interface max iterations);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              for(row = 0; row < data->num_pixels; row++) {
                                                                                                                                                                                                                                                                                                                                                                                                                        interface_num_patterns);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    interface num classes);
                                                                                                                                                                                                                                 interface_num_patterns = data->num_pixels;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 interface num classes = data->num classes;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                interface_num_bands);
                                          data->num_pixels = parameter->train_pats;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    AVSmodify_parameter("Maximum iteration:",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  printf("%d\n", data->label[row]);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        AVSmodify_parameter("Number of bands:",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  interface_num_bands = data->num_bands;
network->rho[ARTb] = parameter->brho;
                                                                                         comp_flag = parameter->complement;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          printf("Interface updated.\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      parameter->b_length);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            network->rho[ARTb]);
```

remap_pixel(parameter, network->pattern[ARTa], comp_flag, min,

printf("ERROR: incorrect status returned by alloc_memory.\n");

return(1);

else

if(status!=1){

#endif

printf("Memory allocated for the network.\n");

net_status->network_loaded = TRUE;

init_ARTMAP(network);

printf("ARTMAP initialized.\n");

for(index=0; index < parameter->b length; index ++) { network->pattern[ARTb][index] = 0.0; class val = data->label[row]; /* encode the class */

network->pattern[ARTb][index+(parameter->b_length)]=1.0; network->pattern[ARTb][class_val] = 1.0;

network->pattern[ARTb][class_val+parameter->b_length]=0.0; if(comp_flag)

/* echo the values to maintain sanity */ #ifdef PROCESS_DEBUG

", network->pattern[ARTa][band]); for(band = 0; band < network->num_att[ARTa]; band++) printf("%1.3f printf("\n");

printf("%1.0f ",network->pattern[ARTb][band]); for(band = 0; band < network->num_att[ARTb]; band++) printf("\nThe input to ARTb is :");

#endif

printf("\n");

refresh_system(network, parameter, net_status); /* refresh the system */

printf("\nDoing ART in the B module.\n"); #ifdef ART DEBUG #endif

printf("Make ARTMAP just entered the training loop.\n");

while (net_status->done_training == FALSE) (

series->num_wrong = 0;

series->num_right = 0;

 $/\star$ step through the training data and train the net $\star/$

gettimeofday(&before, NULL);

#ifdef DEBUG

#endif

net_status->got_all_train_right = FALSE;
net_status->done_training = FALSE;

times_through_training = 0;

B_winner = ART(network, parameter, ARTb, TRAIN); learn (network, parameter, ARTb, B_winner); /* do ART in b */

/* this is the ART loop */

/* initialize loop control variables */ net_status->perfect_mismatch = FALSE;

printf("\nDoing ART in the A module.\n"); #ifdef ART_DEBUG

#endif

printf("Learning iteration %d.\n",times_through_training);

net_status->got_all_train_right = FALSE;

#ifdef DEBUG

#endif

series->num_no_prediction = 0;
net_status->done_training = TRUE; series->num_perfect_mismatch = 0;

A_winner = ART(network, parameter, ARTa, TRAIN); /* do ART in a */

printf("ARTa winner = %d ARTb winner = %d.\n", A_winner, B_winner); #ifdef ART DEBUG

for(band = 0; band < data->num_bands; band ++)

for(row = 0; row < data->num_pixels; row++) {

/* load the pixel into the network field */

row_step = 1.0 / data->num_pixels;

stage = 0.10;

Filename: AVS_makenet.c

Filesize: 28.82 kbytes

recast_inconsistent_cases(BY_MAJORITY, data, parameter);

/* check for and recast inconsistent data */

if(interface_recast){

printf("The fuzzy ARTMAP network has been initialized.\n");

#ifdef DEBUG

#endif

printf("init_ARTs just called.\n"); printf("init ARTb just called.\n");

init_ARTs(network, parameter); init_ARTb(network, parameter); net_status->right = FALSE;
net_status->reset = FALSE;

```
change_confidence(network, parameter, A_winner, 0, TRAIN);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    learn(network, parameter, ARTa, A_winner);
                                                                                                                                                                                                                                                                  for(j=0; j < network->num category[ARIb]+1; j++)
                                                                                                                                                                                                                                                                                                                             max = network->IAMI[A_winner][j];
                                                                                                                                                                                                                                                                                                if(network->IAMI[A winner][j] > max){
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  /* expectation confirmed */
                                                                                                                                             net_status->no_prediction = FALSE;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                net_status->reset = FALSE;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      net_status->wrong = FALSE;
                                                      /* see if this node makes a prediction */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        net_status->right = TRUE;
                                                                                    if(network->makes_prediction[A_winner]) {
                                                                                                                                                                                                         /* determine the prediction */
                                                                                                               net_status->predict = TRUE;
                                                                                                                                                                                                                                                                                                                                                                                                                                                if(prediction == B_winner){
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      printf("expectation confirmed\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               printf("expectation mismatch\n");
                                                                                                                                                                                                                                                                                                                                                         prediction = j;
                                                                                                                                                                                                                                       max = -1.0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         else{
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 #ifdef ART DEBUG
                                                                                                                                                                                                                                                                                                                                                                                                                                                                        #ifdef ART DEBUG
#endif
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          #endif
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           A-45
```

```
printf("expectation mismatch\n");
#endif
    /* expectation mismatch */
    net_status->wrong = TRUE;
    net_status->right = FALSE;
    net_status->reset = TRUE;
    net_status->reset = TRUE;
    net_status->reset = TRUE;
    net_status->perfect mismatch = FALSE;
    IA_reset(network,parameter,net_status,data, series, A_winner,TRAIN,row);
#endif
printf("IA_reset just called.\n");
#ifdef ART_DEBUG
    printf("Changed confidence of node %d.\n", A_winner, 1,TRAIN);
#endif
} /* end if makes prediction */
```

```
Filename: AVS makenet.c
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```
if( (percent_done > stage) && (percent_done < stage + (2 * row_step)) ) (</pre>
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            (series->num right + series->num perfect mismatch != data->num pixels) )
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          times_through_training, times_through_training,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              printf("Maximum iterations = %d.\n", parameter->max_iterations);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            printf("Number correct predictions = %d.\n", series->num_right);
printf("Number of data patterns = %d.\n",data->num_pixels);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         printf("Training iteration = %d.\n",times_through_training);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              if (times through training < parameter->max iterations) &&
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       printf("Done training = %d.\n", net_status->done_training);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 AVS_VALUE | AVS_MINVAL | AVS_MAXVAL,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        AVS_VALUE | AVS_MINVAL | AVS_MAXVAL,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          AVSmodule_status("percent complete", send_val);
                                                                                                                                learn_prediction(network, A_winner, B_winner);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        printf("percent complete %d.\n", send_val);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          percent_done = (float) row/(float)data->num_pixels;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          report_train_performance(network, parameter, series);
                                     learn(network, parameter, ARTa, A_winner);
learn(network, parameter, ARTb, B_winner);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            network->num_category[ARTa]);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              AVSmodify_parameter("ARTa classification nodes:",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         network->num_category[ARTa],
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   network->num_category[ARTa],
                                                                                                                                                                                                                                                                                                                                                                                                                                                          record_train_performance(net_status, series);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        times through training);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                printf("Theses are the training stats.\n");
                                                                                                                                                                                                                                                                    }while(net_status->predict && net_status->reset &&
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   AVSmodify_parameter("Learning iteration:",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     net_status->done_training = FALSE;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 send_val = (int)(100.0 * stage);
                                                                                                                                                                                                                                                                                                                  !net status->perfect mismatch);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         /* report the level of completion */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   /* display training statistics */
/* learn new patterns */
                                                                                                                                                                                                                                                                                                                                                                                                            /* record series performance */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          times through training += 1;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            /* update the interface */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 /* see if we're done */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           /* end of while loop */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 stage += 0.10;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      /* end of row loop */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                #ifdef DEBUG
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    #endif
```

Filesize: 28.82 kbytes

Filename: AVS makenet.c

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*
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          *
AVS FUZZY ARTMAP (1995) Rochester Institute of Technology
                                                                                                                                                                                  ported to ANSI C and the AVS environment by Steven W. Nessmiller **
                                                                                                                                                                                                            This software tool reads in an existing fuzzy ARTMAP neural network
                                                                                                                                                                                                                                   definition file and performs image classification.
                                                                                                                                                                                                                                                                                                                                                                                         support added to skip zero vectors
                                                                                                                                                       ** Original code written by Ah-Hwee Tan **
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     /* this structure supports the input image ^{\star}/
                                                                                                                                                                                                                                                                                                           ANSI C port 15 Feb 1995
AVS port 19 May 1995
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   /* layered debug definitions */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           #include <avs/avs_data.h>
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     #include <sys/types.h>
#include <avs/avs.h>
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         #include <avs/field.h>
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         int num bands;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        #include <sys/time.h>
#include <sys/file.h>
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   #include <avs/flow.h>
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       #define PROCESS_DEBUG
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        #include "memutil.h"
                                                                                                        File Name: main.c
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      #include <string.h>
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  #include "struct.h"
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       #include <stdlib.h>
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              #include <stddef.h>
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 #include "ptypes.h"
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             #include <stdio.h>
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       #define LOAD_DEBUG
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                #include <math.h>
                                                                                                                                                                                                                                                                                                                                                                 1 July 95
                                                                                                                                                                                                                                                                                        Revision history:
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         #include "idef.h"
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   #define MAXSTR 80
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               typedef struct{
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             #define DEBUG
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 A-47
```

```
param=AVSadd_parameter("Parameter file (*.par):","string",cwd,0,".par")
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   "field 2D uniform float", REQUIRED );
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                param=AVSadd_parameter("Network file (*.net):","string",cwd,0,".net");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            create the input port for the input image */
    in_port = AVScreate_input_port("Input Image","field 2D uniform byte",
                                                                                                                                                                                                                                                                                                                                                      void remap_pixel(float *pixel, int length, int flag, float min, float max);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      param=AVSadd_parameter("title","string","Fuzzy ARIMAP Parameters",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           out_port = AVScreate_output_port("Classified Image",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    AVSadd_parameter_prop(param, "width", "integer", 4);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        AVSadd parameter prop(param, "width", "integer", 4);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       AVSset_module_name("Fuzzy ARTMAP", MODULE_FILTER);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  AVSadd_parameter_prop(param,"width","integer",4);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       /\star create the output port for the classification map \star/
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       REQUIRED );
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 /\star create a widget for the parameter filename ^\star/
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 AVSmodule_from_desc (AVS_fuzzy_ARTMAP);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            /* create a widget for the network filename */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            AVSconnect_widget(param, "browser");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            AVSconnect_widget(param, "browser");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         AVSconnect_widget(param, "text");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       /* allow user to view all file types */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             if( cwd[strlen(cwd)-1] != '/')
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    int compute_fuzzy_ARTMAP();
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               set the module name and type */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              /* set the title for the window */
                                                                                                                                                                                                                                          typedef CLASS_MAP *class_map_ptr;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 strcat(cwd,"/");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             int AVS_fuzzy_ARTMAP ();
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        int in_port, out_port;
                                                                                                                                                                                                                                                                                                                                                                                                                                      /\star initialize the modules \star/
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                char cwd[MAXSTR];
                                                                                                                                                                                                                                                                                                                      /* function prototypes */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                /* interface routine */
                                                                               int num_rows;
                                                                                                                       int num_cols;
                                    int **array;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             getwd (cwd);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     AVS_fuzzy_ARTMAP ()
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 AVSinit_modules ()
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    int param;
typedef struct{
                                                                                                                                                              CLASS MAP;
```

 $/\star$ this structure supports the classification map $\star/$

typedef MSI_IMG *msi_img_ptr;

MSI IMG;

int num rows; int num cols; Filename: AVS ART.c

```
param=AVSadd_parameter("Elapsed time (sec):","integer",0,0,INT_UNBOUND);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              param=AVSadd_parameter("Number of training classes:","integer", 0, 0,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           param=AVSadd_float_parameter("Percent classified:", 0.0, 0.0, 100.0);
                                                                                                                                                                                                                                                                                                                                                                                                                       param=AVSadd_parameter("ARTa classification nodes:","integer", 0, 0,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       param=AVSadd_parameter("Auto-generate classification map", "boolean",
param = AVSadd_parameter("View all file types", "boolean",0,0,1);
                                                                                                                                                                                                                                                                                                                                                              \prime^{\star} create a widget to display the number of ARTa classification nodes ^{\star}\prime
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             param=AVSadd_parameter("Generate classification map", "oneshot",
                                                                                                                                                                                                           param=AVSadd_float_parameter("rho for ARTa:", 0.90, 0.1, 1.0);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  /\star create a widget to display the percentage of classified pixels \star/
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        /* create a widget to display the number of target classes */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   param=AVSadd_parameter("Skip zero vectors","boolean",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            AVSadd_parameter_prop(param, "width", "integer", 4);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                AVSadd_parameter_prop(param, "width", "integer", 4);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      AVSadd_parameter_prop(param, "width", "integer", 4);
                                                    AVSadd_parameter_prop(param, "width", "integer",4);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     AVSadd_parameter_prop(param,"width","integer",2);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                AVSadd_parameter_prop(param,"width","integer",2);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 AVSadd_parameter_prop(param,"width","integer",2);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         /* create a widget to generate the classification map */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     AVSconnect_widget(param, "typein_integer");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    AVSconnect_widget(param,"typein_integer");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     AVSconnect_widget(param,"typein_integer");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               AVSset_compute_proc(compute_fuzzy_ARTMAP);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              /\star create a widget to display the elapsed time \star/
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               AVSconnect_widget(param, "typein_real");
                                                                                                                                                                                                                                                               AVSconnect_widget(param, "typein_real");
                                                                                                                                                            /* create a widget to set min rho for ARTa */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     INT_UNBOUND);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                           INT UNBOUND);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                AVSconnect_widget(param, "toggle");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     AVSconnect_widget(param, "toggle");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      /* set the function to create the output */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            0, 0, 0);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           0,0,0
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       AVSautofree_output(out port);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               /* create autogeneration widget */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              /* create autogeneration widget */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 main compute function
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   /* free the output data */
```

```
AVS VALUE, network filename, 0, 0)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             AVS_VALUE, param_filename, 0, 0);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             AVS_VALUE (AVS_MAXVAL, "/tmp/", 0, ".sta");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     AVSmodify_parameter("Parameter file (*.par):",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     int send val, send num nodes, send num classes, elapsed time, dims[2];
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                AVSmodify_parameter("Parameter file (*.par):",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 AVSmodify_parameter("Parameter file (*.par):",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        AVSmodify_parameter("Parameter file (*.par):",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    AVSmodify_parameter("Network file (*.net):",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            AVSmodify_parameter("Network file (*.net):",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                AVSmodify_parameter("Network file (*.net):",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     AVS_VALUE|AVS_MAXVAL, "/tmp/",0,"");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             AVS_VALUE!AVS_MAXVAL, "/tmp/",0,"");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              AVS_VALUE, network_filename, 0, 0);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       AVS_VALUE, param_filename, 0, 0);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            printf( "Setting maxval to null\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   printf( "Setting maxval to .sta\n");
                                                                                                                                                                                                                         float *interface_percent classified,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        if(AVSparameter_changed("View all file types")){
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        int status, flag, A_winner, num_classified, magnitude;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   /* check for view all parameter filenames */
                                                                                                                                                                                    int interface num classes,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            float send_Arho, percent_done, row_step, stage;
                                                                                                                                                                                                                                                                                                 int interface_skip_zeros,
                                                                                                                                                  int interface_num_nodes,
                              char *network_filename,
                                                                                                         float *interface Arho,
char *param_filename,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       static char old_network_filename[80];
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           char *reset_network_filename = " ";
static int first_time_through = 1;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          float min, max, percent_classified;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     static char old_param_filename[80];
                                                                                                                                                                                                                                                                                                                                   int auto_run,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            char *reset_param_filename = " ";
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         parameter_struct_ptr parameter;
                                                                                                                                                                                                                                                               int time,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                struct timeval before, after;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               register int row, col, band;
                                                                          int all
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                class map ptr classified;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               network_data_ptr network;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   FILE *input_network_file;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              if (all) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      static int goodpar = 0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             FILE *input_param_file;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           static int goodnet = 0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  /* local variables */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      else{
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  msi img ptr input;
```

AVSfield_float **output_image,

compute_fuzzy_ARTMAP(AVSfield_char *input_image,

```
parameter=(parameter_struct_ptr)malloc(sizeof(PARAMETER_STRUCTURE))
                                                                                                                                                                                                                                                                         printf("ERROR: unable to allocate the parameter structure.\n^{"});
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      if(network == NULL) {
   printf("ERROR: unable to allocate the network structure.\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            printf("ERROR: bad status returned by read_parameters.\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            network=(network_data_ptr)malloc(sizeof(NETWORK_DATA_STRUCT));
                                      /* allocate the parameter and network structure pointers */ printf("Allocating the parameter structure pointer.\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       printf("Fuzzy ARTWAP needs a valid parameter file.\n"); printf("Use the Make ARTWAP module to create one.\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               /* see if it's a file or a directory */
if (param_filename[strlen(param_filename) - 1] == '/') {
    goodpar = 0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                     printf("Allocating the network structure pointer.\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         goodpar = read_parameters(param_filename, parameter);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           status = strcmp(param_filename, old_param_filename);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      input_param_file = fopen(param_filename, "r+");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           /* display the parameter file to stdout */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            strcpy(old_param_filename, param_filename);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           status = display_parameters(parameter);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    /\star see if the parameter file has changed \star/
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          /* end if first time through */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            if(input_param_file == NULL) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  fclose(input_param_file);
                                                                                                                                                                                                                                  if (parameter == NULL) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   first_time_through = 0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               network->IAMI = NULL;
if (first_time_through) {
                                                                                                                                                                                                                                                                                                                                                       return(1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       return(1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     return(1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    return(1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  if(status i = 0) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        goodpar = 0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            goodnet = 0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                if(goodpar){
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     else(
```

```
parameter->a_length*(1+parameter->complement);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   parameter->b_length*(1+parameter->complement);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        (network filename[strlen(network_filename) - 1] == '/') ( goodnet = 0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             AVSmodify_parameter("Number of training classes:",
AVSmessage("beta", AVS_Warning, NULL, "Make ARTMAP", "Okay", "Paramater file %s is not valid.\n",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  /\star read in the network from disk and allocate memory \star/
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               send_num_classes = network->num_category[ARTb];
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     send_num_nodes = network-> num_category[ARTa];
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       printf("Network file sucessfully loaded.\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          AVSmodify_float_parameter("rho for ARTa:",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  AVS_VALUE | AVS_MINVAL | AVS_MAXVAL,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   AVS VALUE | AVS MINVAL | AVS MAXVAL,
                                                                                                                                                                                                                                                                                                                                       status = strcmp(network_filename, old_network_filename);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       send_num_classes, send_num_classes,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        input_network_file = fopen(network_filename, "r+");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    send_Arho, send_Arho, send_Arho);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               status = load_net(network_filename, network);
                                                                                                                                                                                                                                                                                                                                                                                                                                                   strcpy(old_network_filename, network_filename);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 network->rho[ARTa] = parameter->min_arho;
network->rho[ARTb] = parameter->brho;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         send_Arho = parameter->min_arho;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      /* see if it's a file or a directory */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   /* update the interface */
                                                                                                                                                                                                                                                                                                  /* see if the network file has changed */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      send_num_classes);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             display_net(network);
                                                                   param_filename);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   if (input_network_file == NULL) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          network->num_att[ARTa] =
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 network->num_att[ARTb] =
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              if (network->IAMI != NULL) (
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   free_memory(network);
                                                                                                                                                                                                                                                                                                                                                                                                          if(status != 0 && goodpar) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  if(status==1){
                                                                                                           goodpar = 0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        goodnet = 0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  return(1);
                                                                                                                                                    return(1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         return(1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    else{
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        1.£
```

```
(float)( *(I2DV(input_image, col, row)+band))
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       /* see if we are complementing */
/* values for remap */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  for (band=0; band<network->num_att[ARTa]/2; band++) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    /* map the winning node to a final classification */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     magnitude += network->pattern[ARTa][band];
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               network->target_class[A_winner]+1;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  network->num_att[ARTa],flag,min,max);
                                                           printf("Unable to malloc classification map pointer\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        A_winner = ART(network, parameter, ARTa, TEST);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       if (A_winner == network->num_category[ARTa]) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                /* remap the pixel to between 0 and 1 */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            classified->array[row][col] = 0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      /* do ART and find the winning node */
classified = (class_map_ptr)malloc(sizeof(CLASS_MAP));
if (classified == NULL) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                  0, classified->num_cols-1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        network->pattern[ARTa][band] =
                                                                                                                                                                                                                                                                                                                                                                                                                classified->array = imatrix(0, classified->num_rows-1,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                classified->array[row][col]=
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      if (interface_skip_zeros) && (magnitude == 0) ) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            remap_pixel(network->pattern[ARTa],
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            /* found no good winner */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 for(col=0; col < input->num_cols; col++) {
                                                                                                                                                                                                           /\star set up storage for the resulting class map \star/
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      /*load pixel into pattern */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           num_classified += 1;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               for(row = 0; row < input->num_rows; row++) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 /* refresh the F2 field */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         classified->array[row][col] = 0;
                                                                                                                                                                                                                                                                                                                  input->num_bands = input_image->veclen;
                                                                                                                                                                                                                                                                                                                                                 classified->num_rows = input->num_rows;
                                                                                                                                                                                                                                                                                                                                                                                    classified->num cols = input->num cols;
                                                                                                                                                                                                                                       input->num_rows = MAXY(input_image);
                                                                                                                                                                                                                                                                            input->num_cols = MAXX(input_image);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       refresh F2(network);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      printf("Processing the image.\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            row step = 1.0 / input->num rows;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       magnitude = 0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       flag = parameter->complement;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           gettimeofday(&before, NULL);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    /* process the image */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             else(
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              num_classified = 0;
                                                                                                          return(1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             stage = 0.10;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         max = 255.0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              else (
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      #ifdef DEBUG
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        #endif
                                                                                                                                                                                                                                                                         AVSmessage("beta", AVS_Warning,NULL,"Fuzzy ARTMAP", "Okay", "Could not open network file: %s.\n",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   printf("The selected parameter filename is:%s\n", param_filename);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  printf("The selected network filename is:%s\n", network_filename);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           AVSmodify_parameter("Generate classification map", AVS_VALUE,
                                                                                                                                                                                                                                          printf("ERROR: incorrect status from load net\n");
AVSmodify_parameter("ARTa classification nodes:",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               AVSmodify_float_parameter("Percent classified:",
AVS_VALUE | AVS_MINVAL | AVS_MAXVAL,
                         AVS_VALUE | AVS_MINVAL | AVS_MAXVAL, send_num_nodes,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      printf("Unable to malloc input image pointer\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 AVS_VALUE | AVS_MINVAL | AVS_MAXVAL,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         strcpy(old_network_filename, reset_network_filename);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              AVSmark_output_unchanged("Classified Image");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           strcpy(old_param_filename, reset_param_filename);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         if ( run || auto_run) && (goodnet && goodpar) )
                                                                                                                                                                                                                                                                                                                                           network filename);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  input = (msi_img_ptr)malloc(sizeof(MSI_IMG));
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    0.0, 0.0, 0.0);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           AVSmodify_parameter("Elapsed time (sec):",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         /\star reset parameters from earlier runs \star/
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  /* allocate memory for the structures */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             0, 0, 0);
                                                                                                    send_num_nodes);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  /* reset the static variables */
                                                                                                                                                                                                                                                                                                                                                                             goodnet = 0;
                                                                                                                                   goodnet = 1;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                0,0,0
                                                                                                                                                                                                                                                                                                                                                                                                                return(1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       first_time_through = 1;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              } /* end else */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 return( 1 );
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    if (input == NULL) (
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            return(1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      /* check if run time */
                                                                                                                                                                                                        else(
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   if (goodnet)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    if (goodpar)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       qoodpar = 0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   goodnet = 0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               else (
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  #1fdef DEBUG
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        #endif
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Filename: AVS ART.c

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PAGE
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(AVSdata_alloc ("field 2D uniform scalar float", dims));
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      printf("\nThis node maps to class #%d\n", classified->array[row][col]);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          (float) (input->num_rows * input->num_cols) );
                                                                                                                      printf("%d ", (int) (*I2DV(input_image, col, row) +band));
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       elapsed_time, elapsed_time, elapsed_time);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 if( (percent_done > stage) && (percent_done < stage+(2*row_step) ) ) {</pre>
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              printf("All pixels processed in %d seconds.\n",elapsed_time);
                                                                                                                                                                                                                                                                                                                                                                                                                                                               printf("%1.3f ",network->dn[ARTa][A_winner][band]);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       percent_classified, percent_classified,
                                                                                                                                                                                                              printf("The normalized and complemented pattern is:\n");
                                                                                                                                                                                                                                                                                               printf("%1.3f ",network->pattern[ARTa][band]);
                                                                                                                                                                                                                                                                                                                                                                           printf("This node has the following weight vector:\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            AVS VALUE | AVS MINVAL | AVS MAXVAL,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             AVS_VALUE | AVS_MINVAL | AVS_MAXVAL,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               gettimeofday(kafter, NULL);
elapsed_time = (int) (after.tv_sec - before.tv_sec);
percent_classified = 100.0 * ( (float)num_classified /
                                                                            for(band=0; band < network->num_att[ARTa]/2; band++)
                                                                                                                                                                                                                                                        for (band=0; band < network->num_att[ARTa]; band++)
                                                                                                                                                                                                                                                                                                                                                                                                                     for(band=0; band<network->num_att[ARTa]; band ++)
                                          printf("Given input pixel[%d][%d]:\n", row, col);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 /* update elapsed time and percent classified */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   AVSmodify_float_parameter("Percent classified:",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            AVSmodule_status("percent complete", send_val);
                                                                                                                                                                                                                                                                                                                                     printf("\nARTa's node #%d won.\n", A_winner);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           percent_done = (float)row / (float)input->num_rows;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              AVSmodify_parameter("Elapsed time (sec):",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         *output image = (AVSfield float *)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      printf("percent complete %d\n", send val);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       printf("Allocating the output image.\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              percent_classified);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              /* create the output image field */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           send val = (int) (100.0 * stage);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       dims[0] = classified->num_cols;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 dims[1] = classified->num_rows;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               if(*output_image == NULL) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 /* report level of completion */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                } /* end of row loop */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 } /* end of col loop */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            /* end else */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                printf("\n\n");
                                                                                                                                                                printf("\n");
#ifdef PROCESS DEBUG
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        #ifdef DEBUG
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    #ifdef DEBUG
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      #endif
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        #endif
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     #endif
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```
(AVSdata_alloc ("field 2D uniform scalar float", dims));
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           I2D(*output_image, col, row) = classified->array[row][col];
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         this function remaps the incoming int pixel to a float pixel varying between 0 and 1. Complement coding is automatically supported if flag is set to 1. Values min and max represent the minimal and maximal
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   void remap_pixel(float *pixel, int length, int flag, float min, float max)
                                                                                                                                                                                                                                                                                                                                                                                                                                    printf("Copying the classified image to the output port.\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            0, classified->num_cols-1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   for(col = 0; col < classified->num_cols; col++) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           pixel[index+length/2] = 1.0-remap_value;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        free_imatrix(classified->array,0,classified->num_rows-1,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                if (flag==1) /* indicates complement coding */
                         (dims[1] != MAXX ( *output_image ) ) (
AVSfield_free( (AVSfield *) *output_image);
*output_image = (AVSfield_float *)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            for(row = 0; row < classified->num_rows; row++) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    remap_value = (value - min) / (max-min);
else if ( (dims[0] != MAXX( *output_image )) | |
                                                                                                                                                                                                                                                                                                                                                     /\star copy the class map to the output map \star/
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        for(index=0; index<length/2; index++)(
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           pixel[index]=remap_value;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              /* free all allocated memory */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         status = free_memory(network);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                value = pixel[index];
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                values before the reamp.
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   /* return success */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    free (classified);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 }/* end of remap_pixel */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              float value, remap_value;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             free(parameter);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    free (network);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               free (input);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 function remap pixel
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              } /* end of main */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     register int index;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  return(1);
                                                                                                                                                                                                                                                                                                                                                                                            #ifdef DEBUG
                                                                                                                                                                                                                                                                                                                                                                                                                                                                        #endif
```

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/\star calc and store the resulting classification for each ARTa F2 node \star/
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           printf("Node, weight vector, confidence, predicts category:\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 for(j=0; j < network->num_att[ARTa]; j++)
printf("%1.2f ",network->dn[ARTa][i][j]);
                                                                               network->num_category[ARTa]+1,in_file);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    printf("%d\t", network->makes_prediction[i]);
                                                                                                                                                                                                                                                                                                cat = matching_category(network->IAMI[i],
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           printf("%1.2f\t",network->confidence[i]);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          printf("%d\n", network->target_class[i]);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     for(i=0; i<=network->num_category[ARTa]; i++){
                                                                                                                                                                                                                                               for(i=0; i<=network->num_category[ARTa]; i++){
                                                                                                                                                                                                                                                                                                                                      network->num_category[ARTb]);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  #ifdef LOAD_DEBUG /* echo the net file information */
                                     fread(network->makes_prediction, sizeof(int),
/* read in the predicted category vector */
                                                                                                                                                                                                                                                                                                                                                                        network->target_class[i]=cat;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       printf("%d\t", i);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         printf("\t");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         } /* end of load_network */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              fclose (in_file);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             return(status);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          #endif
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      printf("Number of ARTb categories = %d\n",network->num_category[ARTb]);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               printf("ERROR: allocate_memory returned bad status.\n")
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      printf("Number of ARTa categories = %d\n",network->num_category[ARTa]);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          printf("Number of attributes for ARTa = %d\n",network->num att[ARTa]);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            printf("Number of attributes for ARTb = %d\n", network->num_att[ARTb]);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       /\star read in the number of categories and the number of attributes ^{\star}/
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    printf("These are absolute values and may include complements.\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        printf("ERROR: unable to open user requested network file.\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        network->num_category[ARTb]+1,in_file);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  network->num_category[i]+1, in_file);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          LOAD_DEBUG /* echo the number of attributes and categories */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              for (j=0; jcnetwork->num_category[i]+1; j++)
    fread(network->dn[i][j], sizeof(float),
    network->num_att[i], in_file);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    network->num_category[ARTa]+1,in_file);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           fread(network->num_category, sizeof(int), 2, in_file);
                                                                               Function: Load an ARTMAP neural network from a disk file.
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 fread(network->num_att, sizeof(int), 2, in_file);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            fread(network->committed[i], sizeof(int),
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 for (i=0; i<network->num_category[ARTa]+1; i++)
                                                                                                                                                               int load_net(char *filename, network_data_ptr network)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     /* allocate all the memory for the network */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          fread(network->IAMI[i], sizeof(float),
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        /* read in the weight vectors */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              fread(network->confidence, sizeof(float),
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        /* read in the confidence vector */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        /* read in the committed vector */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          printf("Exiting to system...\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           status = alloc_memory(network);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     if (status !=1) {
                                                                                                                                                                                                                                                                                                                                                                                                          in_file = fopen(filename, "rb");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  exit(1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           /* read in the IAM */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  for (i=0; i<2; i++) {
                                     Routine Name : Load Net
                                                                                                                                                                                                                                               register int i, j;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          if(in_file==NULL){
                                                                                                                                                                                                                                                                                     int status, cat;
                                                                                                                                                                                                                                                                                                                              *in_file;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       exit(1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       #1fdef
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      #endif
                                                                                                                                                                                                                                                                                                                              FILE
```

Filesize: 23.28 kbytes

Filename: AVS ART.c

```
printf ("... initializing random number generator by time\n\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             for (inity = 0; inity < network->num_category[ARTb]+1; inity++)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     printf("Initializing random generator using %d\n",
                              printf ("Frequency of Category %d = %d\t %1.1f%%\n", i+1,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        for (initx = 0: initx < network->num_category(ARTa)+1; initx++) {
    network->confidence[initx] = baseline_confidence;
                                                                                                                                                                                                                                                                                                                                                                       /*----
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         Function: Initialize ARIMAP network in particular the data structure
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        Function: Given two vectors, determine whether they are identifical.
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               int equal_input(parameter_struct_ptr parameter, float *v1, float *v2)
                                                                                                         100*data->frequency[i]/(float)num_pats);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     of ARTa F2 recognition nodes.
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  network->IAMI[initx][inity] = 0.0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               network->makes_prediction[initx] = FALSE;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    parameter->randomInit);
for (i=0; i<parameter->num_data_category; i++)
                                                                                                                                                                                                                                                                                                                                                                                                             void init_random(parameter_struct_ptr parameter)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    network->freeze[initx] = FALSE;
                                                                                                                                                                                                                                                                                                                                  Function: Initialize random number generator.
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   srand(parameter->randomInit);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       for (j=0; j<parameter->a_length; j++)
if (v1[j] != v2[j])
                                                                          data->frequency[i],
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             if (parameter->trace >= 1)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     void init_ARTMAP(network_data_ptr network)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         if (parameter->trace >= 1)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    if (parameter->randomInit == 1) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     return (FALSE);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                srand(time(NULL));
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       float baseline_confidence = 1.0;
                                                                                                                                                                                                                                                                                                Routine Name : Init Random
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          Routine Name : Init_ARTMAP
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   Routine Name : Equal_Input
                                                                                                                                              printf ("\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           return (TRUE);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        else{
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             int initx;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  int inity;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          int j;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       printf ("Number of Data Category = %d\n", parameter->num_data_category);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     B_winner = data_category(network->pattern[ARTb], parameter->b_length,1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       Function: Before learning, preprocess the data vectors to determine
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             the frequency of each data category.
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            data->Index[firstIndex] = data->Index[secondIndex];
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               for (firstIndex = 0; firstIndex < num_pats; firstIndex++) {</pre>
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          void pre_scan_data[data_struct_ptr data, network_data_ptr network,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               B_winner = parameter->num_data_category;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      parameter_struct_ptr parameter, int num_pats)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               Function: Randomize the Indices of first num_pats patterns.
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 data->Index[secondIndex] = holdingTank;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          holdingTank = data->Index[firstIndex];
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              for(i=0; i<=parameter->num_data_category; i++)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              data->frequency[B_winner]++;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          void setup_index(data_struct_ptr data, int num_pats)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     secondIndex = rand() %num pats;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          data->frequency[i] = 0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              for (i=0; i<num_pats; i++) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          data -> Index[i] = i;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               read_pattern (i); in io.c
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    for(i=0; i<num pats; i++)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          if (B_winner=-1)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  Routine Name : pre_scan_data
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                Routine Name : setup_index
                                                                                                                                                                                                                                                           #include <sys/types.h>
                                                                                                                                                                                                                                                                                                #include <stdlib.h>
                                                                                                                                                                                                                                                                                                                                                                                                                                               #include "struct.h"
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    #include "ptypes.h"
                                                                   Filename imp_art.c
                                                                                                                                                                                                                     #include <stdio.h>
                                                                                                                                                                                                                                                                                                                                     #include <math.h>
                                                                                                                                                                                                                                                                                                                                                                       #include <time.h>
                                                                                                                                                                                                                                                                                                                                                                                                             #include "idef.h"
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          int firstIndex;
int secondIndex;
int holdingTank;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             int i, B_winner;
```

Filesize: 15.75 kbytes

Filename: imp_art.c

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network->pattern[ARTb][data->label[pc]+parameter->b_length] = 0.0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      determine the ARTb category that it predicts.
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          for (i=parameter->b_length; i<network->num_att[ARTb]; i++)
                                                                                                                                                                                                    printf ("WARNING: Error in class of pattern %d.\n", pc);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 Initialize all attached attributes.
                                                                                                                                                                                                                                                                                                                                                                                                                                                                void relabel(data_struct_ptr data, parameter_struct_ptr parameter,
                                                                                                                                                                                                                                                                                                                                                                                                           Function: Modify the data category of the current data vector.
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         Function: Given the inter-ART map field vector and its length,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     network->pattern[ARTb][i] = 1.0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        for(i=0; iifor(i=0; icparameter->D_length: i++)
network->pattern[ARTb][i] = 0.0;
network->pattern[ARTb][data->label[pc]] = 1.0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    Function: Reset a node to be uncommitted node.
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           network_data_ptr network, int pc)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            int matching_category(float *v, int n)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             max = v[i];
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               Routine Name : Matching_Category
                          num_cat++;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             if(parameter->complement)(
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          max i = i;
cat = i;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                if (v[i]>max) {
                                                                                                                                            return (cat);
                                                                                                                                                                                                                                 return (-1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   for (i=0; i<n; i++)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            Routine Name : Destroy
                                                                                                                                                                                                                                                                                                                                                                                 Routine Name : Relabel
                                                                                                                  if(num_cat==1)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           max = -1.0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             return (max i);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   i, max_i;
                                                                                                                                                                          else(
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 float max;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   int i;
                                                                                                                                                                                                                                                                                         for (present_x = 0; present_x < network->num_att[whichART]; present_x++)
                                                                                                                                                                                                                                                                                                                    Function: Given a binary vector and its length, determine the data
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        Function: Test whether a perfect match between the input and the
                                                                                                               Function: Determine whether input is present in an ART module.
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                category that it indicates.
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        int perfect_match(network_data_ptr network, int A_node)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     if (matchFunction(network,ARTa, A_node) == 1.0)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    Function: Normalize a vector so that it's norm is 1.
                                                                                                                                                                       int present(network_data_ptr network, int whichART)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     int data_category(float *v, int n, int pc)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        template vectors has occurred.
                                                                                                                                                                                                                                                                                                                                                    return (TRUE);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        v[i] = v[i]/sum;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            void normalize (float *v, int n)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               num_cat = 0;
for (i=0; i<n; i++)
   if (v[i]>0.5){
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              Routine Name : Perfect_Match
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          return (FALSE);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        Routine Name : Data_Category
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                return (TRUE);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      sum += v[i];
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              for (i=0; i<n; i++)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      for (i=0; i<n; i++)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          Routine Name : Normalize
                                                                                  Routine Name : Present
                                                                                                                                                                                                                                                                                                                                                                              return (FALSE);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               int i, num_cat, cat;
                                                                                                                                                                                                                               int present_x;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            float sum=0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             else
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 int i;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     A-54
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Filesize: 15.75 kbytes

Filename: imp_art.c

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netstat_ptr netstat, data_struct_ptr data, series_data_ptr series,
                                                                                                                                                                                                                                                                                                                                                                                                                    parameter->wt[destx%padamateh-%xab&n(gek%pork_data_ptr network, parameter_struct_ptr parameter,
                                                                                                                                                                                                                                                                                                                                                                                                                                                           netstat_ptr netstat, data_struct_ptr data, series_data_ptr series,
                                                                                                                                                                                                                                                                                                                               a reset. If new vigilance is greater than 1, indicate perfect mismatch.
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      printf("WARNING: PERFECT_MISMATCH ON PATTERN %d:(%d)\n",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    network->vg[0][A_node],match, A_node, phase,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                void IA reset(network data ptr network, parameter struct ptr parameter,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     printf ("category %d\n", A_node);
display_pattern("2",network->dn[ARTa][A_node],
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             match_track(network, parameter, netstat, data, series,
                                                                                                                                                                                                                                                                                        Function: Increase the vigilance by the amount just enough to cause
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          Function: Initial inter-ART reset by performing matching tracking.
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  display_pattern("I", network->pattern[ARTa],
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      float vg, float match, int A_node, int phase, int pat_id)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       network->num_att[ARTa]);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             network->num_att[ARTa]);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               netstat->got_all_train_right = FALSE;
network->F2[0][A_node] = -1;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 pat_id+1, data->Index[pat_id]+1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 match = matchFunction(network, ARTa, A_node);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           netstat->perfect_mismatch = TRUE;
                                                                         network->makes_prediction[A_node] = TRUE;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  vg = match + parameter->epsilon;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         series->num perfect mismatch++;
                                   network->IAMI[A_node][B_node] = 1.0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        if (vg < match + parameter->epsilon)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  (parameter->trace >=1 ){
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              int A node, int phase, int pat_id)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    if (vg >= 1.0 && phase==TRAIN) (
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               pat id);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            if(phase -- TRAIN)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       if(parameter->ind_vg)
                                                                                                                                                                                                                                                 Routine Name : Match_Track
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   Routine Name : IA reset
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  11
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          else{
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          else
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               float match;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     parameter_struct_ptr parameter, int A_node, int reduce_confidence, int phase)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        (1.0 - network->confidence(A_node) - reduce_confidence);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 network->dn[ARTa][A_node][destx] = parameter->dnInit;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               if (network->confidence[A_node] < parameter->noise_tolerance)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                prediction success. This subroutine adjusts the confidence of nodes
                                                                                                                                                                                                                                                                            if (parameter->employ weighting)
for (destx = 0; destx < network->num_att[ARTa]; destx++)
network->dn[ARTa][A_node][destx] =
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      (destx = 0; destx < network->num_att[ARTa]; destx++)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  for (destx = 0; destx < network->num_category[ARTb]+1; destx++)
void destroy (parameter_struct_ptr parameter, network_data_ptr network,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        void learn_prediction(network_data_ptr network, int A_node, int B_node)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   /*-----
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          network->confidence[A_node] += parameter->noise_rate *
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       printf ("ARTa category %d destroyed.\n", A_node+1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     Function: Update confidence of a Recognition node with respect to
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               Function: Update inter-ART map field to make the association. Set
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           according to whether they just made a correct prediction
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          destroy (parameter, network, A_node);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           for(lpx = 0; lpx < network->num_category[1]+1; lpx++)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  (reduce_confidence = 0) or an incorrect prediction
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               network->confidence[A_node] = baseline_confidence;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              network->vg[ARTa][A_node] = parameter->min_arho;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              make_prediction of the ARTa F2 node to be true.
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         network->IAMI[A_node][destx] = 0.0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      network->makes_prediction[A_node] = FALSE;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           network->committed[ARTa][A_node] = FALSE;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      network->IAMI[A_node][lpx] = 0.0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      void change_confidence (network_data_ptr network,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 network->freeze[A_node] = FALSE;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                if (parameter->trace >= 2)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              Routine Name : Change Confidence
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         (reduce_confidence = 1).
                                                                                                                                                               float baseline_confidence = 1.0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        Routine Name : Learn_Prediction
                                      int A_node)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       if(phase == TRAIN)(
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      for
                                                                                                                                                                                                                                                                                                                                                                                                                                                                   else
                                                                                                                        int destx;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             int lpx;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                A-55
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printf ("Recasting inconsistent cases. Please wait ... \n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       for (s=r+1; s<data->num_pixels; s++)
   if (recasted[s]==FALSE && equal_input(parameter,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             recasted = (int *) malloc (sizeof(int)*data->num_pixels);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       for (i=0; i<parameter->b_length; i++) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                vote = (int *)malloc(sizeof(int)*parameter->b_length);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    recasted_label = 1;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 max_v = vote[i];
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           vote[data->label[s]]++;
                                   er int r, s, i;
*recasted, *vote, *num in_cat;
max_v, recasted_label, tot_vote, num_recasted;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      for (i=0; i<parameter->b_length; i++)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          if (vote[i] > max_v) (
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        recasted[s] = EXAM;
                                                                                                                                                                                                                                                                                                    printf ("No recasting ... \n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              for (r = 0; r < data->num_pixels; r++)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             recasted_label = -1;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            for (r=0; r<data->num_pixels-1; r++)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  tot_vote++;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   if (recasted[r] -- FALSE) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          vote[data->label[r]] = 1;
                                                                                                                                                                                                                                                                    if (parameter->trace>=1)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   if (mode==BY MAJORITY) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          max_v = -999;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             vote[i] = 0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 recasted[r] = FALSE;
                                                                                                                                                    chance, accum_vote_fraction;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       recasted[r] = EXAM;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                   if (parameter->trace>=1)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    tot_vote = 1;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              num_recasted = 0;
                                                                                                                                                                                                                                                                                                                                                  return;
                                                                                                                                                                                                                                 if (mode==0) {
                                      register int
                                                                                                                                                       float
                                                                             int
                                                                                                                int
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   void A_only(network_data_ptr network, parameter_struct_ptr parameter, int phase
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      void B_only(network_data_ptr network, parameter_struct_ptr parameter, int phase
                                                                                                                                                                                                                                                                                                                                                                                                                     has identified a winner while ART-A returns to its search cycle. It is
                                                                                                                                                                                                                                                             clear F2 activities. When network makes first prediction, this is set
                                                                                                                                                                                                                                                                                                                                               errors by prediction type. If AB, ART-A receives input first. After
                                                                                                                                                                                                                                                                                                                                                                                     an inter-ART mismatch reset, order is set to BA indicating that ART-B
                                                                                                                                                                                                                                                                                                        to the index of the predicted ART-B node. It is used to keep track of
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             void refresh_system(network_data_ptr network, parameter_struct_ptr parameter,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 learn(network, parameter, ARTb, ART(network, parameter, ARTb, TRAIN));
                                   network->rho[0], match, A_node, phase, pat_id);
                                                                                                                                                                                                                          Function: Called before each input presentation. Initialize variables and
                                                                                                                                                                                                                                                                                                                                                                                                                                                            possible to allow ART-B to initially receive its pattern first by
match_track(network, parameter, netstat, data, series,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              Routine Name : Recast_Inconsistent_Cases
Function: Perform preprocessing to remove inconsistency in data
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                Function: Only ARTa has input. Perform ART learning in ARTa.
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               Function: Only ARTb has input. Perform ART learning in ARTb.
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        ART (network, parameter, ARTa, TRAIN) );
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       network->rho[ARTa] = parameter->min_arho;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              learn(network, parameter, ARTa,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              network->first_prediction[0] = -1;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    netstat->no_prediction = TRUE;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   setting order to BA here.
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             netstat->wrong = FALSE;
                                                                                                                                                                                   Routine Name : refresh_system
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                netstat_ptr netstat)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              netstat->order = BA;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     refresh F2 (network);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          if (phase == TRAIN)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         Routine Name : A_only
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         Routine Name : B_only
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       if (phase == TRAIN)
```

accum_vote_fraction += vote[i]/(float)tot_vote;

for (i=0; i<parameter->b_length; i++) {

chance = (rand()%100)/100.0;

else if (mode==BY_PROBABILITY) {

accum_vote_fraction = 0.0;

void recast_inconsistent_cases(int mode, data_struct_ptr data,

vectors.

parameter_struct_ptr parameter)

Filename: imp art.c

```
for (i=0; icparameter->b_length; i++)
printf ("Number in Category %d = %d\n", i, num_in_cat[i]);
printf ("\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              printf (">> Total of %d cases recasted.\n\n", num_recasted);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     void record_train_performance(netstat_ptr netstat, series_data_ptr series) {
                                                                                                                                                                                                                      if (recasted[s] == EXAM) {
   if (data->label[s] != recasted_label) {
     data->label[s] = recasted_label;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       num_in_cat = (int *)malloc(parameter->b_length*sizeof(int));
if (chance < accum_vote_fraction) {
    recasted_label = i;</pre>
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              Function: Record prediction performance during training in : num_no_prediction, num_wrong and num_right.
                                                                                                                                                                                                                                                                                                      num_recasted++;
                                                                                                                                                                                          for (s = r; s < data->num_pixels; s++)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           series->num_no_prediction++;
                                                                                                                                                                                                                                                                                                                                                                   recasted[s] = TRUE;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       Routine Name : Record_Train_Performance
                                                        break;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        series->num_right++;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         series->num_wrong++;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           if (netstat->no_prediction)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     if (parameter->trace>=1) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          if (netstat->wrong)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            if (netstat->right)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              free(num_in_cat);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           free (recasted);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    free (vote);
```

Filename: imp_art.c

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this function returns the degree to which the input pattern is a fuzzy subset
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           of the weight vector. The resulting vlaue is used to determine if resonance
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                and f2 is the index of the F2 node being examined. Mathematically speaking,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            for (refy = 0; refy < network->num_category[refx]+1; refy++)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      pattern. The value of whichART determines which ART module is being queried
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    if(network->pattern[whichART][mfx]<network->dn[whichART][f2][mfx])
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   Function: Compute the match of the input pattern to the weight template.
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          float matchFunction(network_data_ptr network, int whichART, int f2)
   network->pattern[1][i+parameter->b_length] = 0.0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            Function: Compute the match of the weight template to the input
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     /* the numerator of the match value */
/* the denominator of the match value */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              numerator += network->pattern[whichART][mfx];
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         numerator += network->dn[whichART][f2][mfx];
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           denominator += network->pattern[whichART][mfx];
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     network->F2[refx][refy] = 0.0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 for(mfx=0; mfx < network->num att[whichART]; mfx++) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 occurrs between the input and classification fields.
                                                                                                                                                                                                                                                                                                                                                                          Function: Clear the ARTa and ARTb F2 activities.
                                                                                      B_only (network, parameter, TRAIN);
                                                                                                                                                                                                                                                                                                                                                                                                                                                              void refresh_F2(network_data_ptr network)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       printf("F2 field refreshed.\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         return (numerator/denominator);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      for(refx=0; refx<2; refx++)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 Routine Name : ChoiceOrderFunction
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       Routine Name : MatchFunction
                                                                                                                                                                                                                                                                                                                                     Routine Name : Refresh F2
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     #ifdef FUZZY DEBUG
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  float denominator;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           denominator = 0.0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         float numerator;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  numerator = 0.0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   int refy;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             int refx;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       int mfx;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    #endif
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  for(inity = 0; inity < network->num_att(initx); inity++)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              for(inity = 0;inity < network->num_att[initx];inity++)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    network->dn[initx][initz][inity] = _arameter->dnInit;
                                                                                                                                                                                                    /* header containing data structure definitions */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 parameter->wt[inity%parameter->a_length];
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  network->pattern[1][j+parameter->b_length] = 1.0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       void init_ARTs(network_data_ptr network, parameter_struct_ptr parameter)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             void init_ARTb(network_data_ptr network, parameter_struct_ptr parameter)
                                                                                                                                                                  /* header with various network definitions */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   for(initz=0;initz < network->num_category[initx]+1;initz++) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              network->vg[initx][initz] = network->rho[initx];
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    if (parameter->employ_weighting && initx==ARTa)(
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       network->dn[initx][initz][inity] =
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  Function: Write the patterns to a file in binary format.
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               Function: Initialize ARTs vaiables and weight templates.
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         network->committed[initx][initz] = FALSE;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                network->rho[ARTa] = parameter->min_arho;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     for (j=0; jjjfor (j=0; jpartern[1][j] = 0.0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  network->rho[ARTb] = parameter->brho;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        if (parameter->complement)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               for (i=0; i<parameter->b_length; i++) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             network->pattern[1][i] = 1.0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   if (parameter->complement)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     for(initx=0; initx<2; initx++)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                refresh_F2 (network);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  Routine Name : Init_ARTs
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        Routine Name : Init_ARTB
                                  #include <sys/types.h>
                                                                                                                                                                                                        #include "struct.h"
                                                                               #include <stdlib.h>
                                                                                                                                                                                                                                                 #include "ptypes.h"
                                                                                                                                                                                                                                                                                                                                                                   #define FUZZY_DEBUG
#include <stdio.h>
                                                                                                                        #include <math.h>
                                                                                                                                                              #include "idef.h"
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                int inity;
int initz;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          int initx;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             int i, j;
```

Filename: imp fuz.c

The

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the index of the F2 node being examined. Mathematically, this function returns
value of whichART determines whether ARTa or ARTb is being querried, and f2
```

```
parameter_struct_ptr parameter, int whichART, int f2)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    for (cofx=0.cofx < network->num_att[whichART];cofx++) (
   denominator += network->dn[whichART][f2][cofx];
if(network->pattern[whichART][cofx] < network->dn[whichART][f2][cofx])
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                numerator += network->pattern[whichART][cofx];
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    numerator += network->dn[whichART][f2][cofx];
                                                                                                                                                                                                                                                                                                                                                                                                                                            if (network->F2[whichART][f2]==-1.0) /* if the node is "sleeping" */
the degree to which the weight vector is a fuzzy subset of the input vector.
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            int ARTreset(network_data_ptr network, parameter_struct_ptr parameter,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        Function: Simulate ART reset by turning the activated F2 node off.
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         (!parameter->ind_vg && matchFunction(network,whichART,f2)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 printf("RESET: ARTreset(%d,%d).\n",whichART,f2);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 if ((parameter->ind_vg && matchFunction(network,whichART,f2) <</pre>
                                                                                                                                                                                                                                                                                                                                                        float denominator; /* the denominator of the choice value */
                                            The result values is used to determine the winning F2 node
                                                                                                                                                                                                                                                                                                            /* the numerator of the choice value */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        int whichART, int f2)
                                                                                                                                    float choiceOrderFunction(network_data_ptr network,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             network \rightarrow F2[whichART][f2] = -1.0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            denominator += parameter->Alpha;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    return (numerator/denominator);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             network->vg[whichART][f2]) ||
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    denominator = 0.0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 network->rho[whichART])) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            numerator = 0.0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        return (-1.0);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         return (TRUE);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            else
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            Routine Name : ARTreset
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         #ifdef FUZZY DEBUG
                                                                                                                                                                                                                                                                    register int cofx;
                                                                                                                                                                                                                                                                                                            float numerator;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                else{
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             #endif
```

int ART(network_data_ptr network, parameter_struct_ptr parameter, int whichART,

Last Updated: Thu Aug 31 01:16:37 1995

```
network->F2[whichART][f2]=choiceOrderFunction(network, parameter, whichART, f2);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      if (winner==network->num_category[whichART] && phase==TRAIN){ /* make a new no
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            mismatch = ARTreset (network, parameter, whichART, winner);
                                                                                                       /* binary: 0 means no chosen node has matched yet */
                                                                                                                                                                                                                                                                     /* detrmine the activations for each f2 node in the ART module */
                                                                                                                                                                                                                                                                                                                                                                                                                                                               /* if testing, set the uncommited F2 node activation to zero. */ if (phase==TEST) (
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     maxChoice = network->F2[whichART][f2];
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            Function: Modify ART weight template according to the learning rule.
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          for(f2=0; f2<=network->num_category[whichART]; f2++)(
                                                                                                                                                                                      /\star the current f2 node under consideration \star/
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  if (maxChoice < network->F2[whichART][f2]) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        printf("The degree of agreement is %1.3f\n",maxChoice);
printf("This value must be >= %1.3f to be classified.\n",
                                                                    /* highest choice value found so far */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              for(f2=0; f2<=network->num_category[whichART]; f2++)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      for(f2=0; f2<=network->num_category[whichART]; f2++)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          printf("%1.3f ",network->F2[whichART][f2]);
                                                                                                                                                                                                                                                                                                         for(f2=0; f2<=network->num_category[whichART]; f2++)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            realloc_memory(network,parameter,whichART);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        new_weight = beta*(Input^old_weight)+(1-beta)*old_weight
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         network->F2[whichART][f2] = 0.0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 if (!network->committed[whichART][f2])
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        network->num_category[whichART]++;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      printf("The F2 activation vector is:\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    network->rho[whichART]);
                                                                                                                                               /* the winning f2 node */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             winner = f2;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               maxChoice = -1.0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       winner = -1;
int phase)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       } while (mismatch);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       Essentially accomplishes
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  return (winner);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         Routine Name : Learn
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     printf("\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  #ifdef FUZZY DEBUG
                                                                    float maxChoice;
                                                                                                       int mismatch;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               op (
                                                                                                                                               int winner;
                                                                                                                                                                                      int f2;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  #endif
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              /* ab
```

Function returns the winning node foran ART module as determined by the value

Routine name ART

whichART

return (FALSE);

else

```
void learn(network_data_ptr network, parameter_struct_ptr parameter,
    int whichART, int f2)
int learn_x;
float cur_rate;

if (network->committed[whichART][f2])
    cur_rate = parameter->rate;

else
    cur_rate = 1.0;

for (learn_x = 0; learn_x < network->num_att[whichART]; learn_x++)

if(network->pattern[whichART][learn_x]<network->dn[whichART][f2][learn_x])

network->cur_rate*network->dn[whichART][learn_x];

network->committed[whichART][f2] = 1;

network->committed[whichART][f2] = 1;
}
```

A-60

Filesize: 8.22 kbytes

```
/* this kluge seems important */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    (void)sscanf (line, "%d", &parameter->display_confusion_matrix);
                                                                                                                                                                                                                                                                                                             (void) sscanf (line, "%d", &parameter->num_data_category);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                (void)sscanf (line, "%d", &parameter->incorporate_rules);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 (void)sscanf (line, "%d", &parameter->quantization_step);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          (void)sscanf (line, "%f", &parameter->noise_tolerance);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             (void)sscanf (line, "%d", &parameter->quantize_rules);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          (void) sscanf (line, "%d", &parameter->num F2_winners);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     (void) sscanf (line, "%d", &parameter->extract rules);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       (void) sscanf(line, "%d", &parameter->on_line_recast);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               (void) sscanf (line, "%d", &parameter->trace_weight);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               (void)sscanf (line, "%f", &parameter->u_threshold);
(void)fgets (line, sizeof(line), in_file);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          (void)sscanf(line, "%d", &parameter->predict_pats);
                                        (void)sscanf (line, "%d", &parameter->complement);
(void)fgets (line, sizeof(line), in_file);
                                                                                                                                                                                                                                                                                                                                                                                                 (void)sscanf (line, "%d", &parameter->train_pats);
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                                                                                                                                (void)sscanf (line, "%d", &parameter->a_length);
(void)fgets (line, sizeof(line), in_file);
                                                                                                                                                                                                                         (void) sscanf (line, "%d", &parameter->b_length);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              (void)sscanf(line, "%d", &parameter->test_pats);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             (void)sscanf (line, "%f", &parameter->min arho);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            (void) sscanf (line, "%f", &parameter->epsilon);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  (void) sscanf (line, "%d", &parameter->ind_vg);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        (void) sscanf (line, "%f", &parameter->Alpha);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     (void) sscanf (line, "%f", &parameter->z_bar);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   (void)sscanf (line, "%d", &parameter->trace);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                (void)sscanf (line, "%f", &parameter->rate);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  (void) sscanf (line, "%f", &parameter->brho);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               (void)fgets (line, sizeof(line), in_file);
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                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   (void) fgets (line, sizeof(line), in_file);
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(void) fgets (line, sizeof(line), in_file);
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                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           (void) fgets (line, sizeof(line), in file);
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                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        (void) fgets (line, sizeof(line), in file);
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                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              (void) fgets(line, sizeof(line), in_file);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           (void) sscanf(line, "%f", &float_dummy);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           if (parameter->employ_weighting) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   parameter->dnInit = float_dummy;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             This function loads in the user defined parameters for the neural network.
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       printf("Cannot open requested parameter file.\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     int read_parameters(char *filename, parameter_struct_ptr parameter)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  (void)sscanf (line, "%d", &parameter->employ_weighting);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       (void)sscanf (line, "%d", &parameter->max_iterations);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    printf("Exiting from program.\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             (void) sscanf (line, "%d", &parameter->randomInit);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             (void)sscanf (line, "%d", &parameter->orderedSet);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              (void) sscanf (line, "%d", &parameter->num_voters);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               (void) sscanf (line, "%d", &parameter->num_runs);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          (void) sscanf (line, "%d", &parameter->on_line);
                                                                                                                                                                                                                                                                                                                                                                                                                                              Function: Display a pattern with a header string.
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  (void)fgets (line, sizeof(line), in_file);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           (void) fgets (line, sizeof(line), in_file);
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                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               printf ("%s = {", str);
   for (1=0; i<n; i++)
        printf ("%1.21f,", v[1]);</pre>
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     (void) fgets (line, sizeof(line), in_file);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     (void) fgets (line, sizeof(line), in_file);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           (void) fgets (line, sizeof(line), in_file);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              void display_pattern(char *str, float *v, int n)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                (void) fgets (line, sizeof (line), in_file);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   in_file = fopen(filename, "r");
                                                                                                                                                                                                                                                                                                                                                                                             Routine Name : display_pattern
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                exit(1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   printf (")\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                function read parameter
                                            #include <sys/types.h>
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               if (!in_file) {
                                                                                                                                                                                                                                                                 #include "memutil.h"
                                                                                    #include <stdlib.h>
                                                                                                                                                                            #include "struct.h"
                                                                                                                                                                                                                     #include "ptypes.h"
#include <stdio.h>
                                                                                                                                #include "idef.h"
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              register int j;
char line[200];
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              float float_dummy.
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          *in_file;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      status;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  int i;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              FILE
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Filename: imp io.c

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                                                                                                                                                                                    }/*end of display parameter
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        if (lout_file) (
                                                                                                      return(status);
                                                         status=1;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       fprintf
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                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     printf ("Number of data categories/t\t : %d\n", parameter->num_data_category);
parameter->ut = (float *)malloc(parameter->a_length*sizeof(float));
for (j=0: j<parameter->a_length; j++)
    fscanf (in_file, "%f", &parameter->wt[j]);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 printf ("Incorporating rules\t\t\t : %d\n", parameter->incorporate_rules);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            printf ("No. of predict patterns\t\t\t: %d\n", parameter->predict_pats);
printf ("No. of test patterns\t\t\t: %d\n", parameter->test_pats);
printf ("Initial weight\t\t\t\t: %1.3f\n", parameter->dnInit);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           printf ("Number of training patterns\t\t : %d\n", parameter->train_pats);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        printf ("Noise tolerance\t\t\t\t\t : %1.3f\n", parameter->noise tolerance);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     printf ("Quantization step\t\t\t : %d\n", parameter->quantization_step);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              printf ("Number of F2 winners\t\t\t : %d\n", parameter->num_F2_winners);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            printf ("Complement coding\t\t\t: \d\n", parameter->complement);
printf ("Feature weighting\t\t\t: \d\n", parameter->employ_weighting);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    printf ("Minimum ARTa vigilance\t\t\t : %1.3f\n", parameter->min_arho);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    printf ("On line recasting\t\t\t : %d\n", parameter->on_line_recast);
printf ("Number of voters\t\t\t : %d\n", parameter->num voters);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           printf ("Number of attributes ARTa\t\t : %d\n", parameter->a_length);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        printf ("Number of attributes ARTb\t\t : %d\n", parameter->b_length);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        printf ("Quantizing rules\t\t\t : %d\n", parameter->quantize_rules);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          printf ("Extracting rules\t\t\t : %d\n", parameter->extract_rules);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      printf ("Random number seed\t\t\t : %d\n", parameter->randominit);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       ("Individual vigilance t /t/t : %d/n", parameter->ind_vg);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              ("Trace weight/t/t/t/t : %d/n", parameter->trace_weight);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               printf ("Noise rate\t\t\t\t\t : %1.3f\n", parameter->noise rate);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            /*-----
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           ("Number of runs/t/t/t : %d/n", parameter->num runs);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       ("Ordered set/t/t/t/t : %d\n", parameter->orderedSet);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           printf ("On line learning\t\t\t : %d\n", parameter->on_line);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             printf ("ARTb Vigilance\t\t\t\t : %1.3f\n", parameter->brho);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    parameter->display_confusion_matrix);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              printf ("Learning rate\t\t\t\t\t : %1.3f\n", parameter->rate);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          ("Threshold\t\t\t\t : %f\n", parameter->u_threshold);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             printf ("Epsilon\t\t\t\t\t\t\t : %1.3f\n", parameter->epsilon);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    printf ("Maximum number of training iterations\t : %d\n",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     printf ("Trace level\t\t\t\t : %d\n", parameter->trace);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   printf ("Z-Bar\t\t\t\t\t\t\\t : %1.3f\n", parameter->z_bar);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    printf ("Alpha\t\t\t\t\t\t : %1.3f\n", parameter->Alpha);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      parameter->max_iterations);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     int display_parameters(parameter_struct_ptr parameter) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           printf ("Display confusion matrix/t/t : %d\n",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              Function: Display parameters to stdout.
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 Routine Name : Display_Parameter
                                                                                                                                                                                                                                                                                                                                                                                                                  }/* end of get_parameters */
                                                                                                                                                                                                                                 fclose (in_file);
                                                                                                                                                                                                                                                                                                                            return(status);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 printf ("\n");
                                                                                                                                                                                                                                                                               status = 1;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            printf
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           printf
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  printf
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fprintf (out file,"%d\t\t\t Complement coding\n", parameter->complement);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      (out_file,"%d\t\t On line recasting\n", parameter->on_line_recast);
(out_file,"%1.3f\t\t Initial weight\n", parameter->dnInit);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           (out_file,"%d\t\t\t Random number seed\n", parameter->randomInit);
(out_file,"%d\t\t\t Ordered set\n", parameter->orderedSet);
(out_file,"%d\t\t\t Feature weighting\n",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             (out_file,"%d\t\t\t Number of voters\n", parameter->num_voters);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           (out_file, "%d\t\t\t Trace weight\n", parameter->trace_weight);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         (out_file,"%d\t\t\t On line learning\n", parameter->on_line);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              (out file, "%1.3f/t/t/t Noise rate\n", parameter->noise_rate);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    (out_file,"%d\t\t\t Maximum number of training iterations\n",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              (out_file,"%d\t\t\t Number of runs\n", parameter->num_runs);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         fprintf (out file,"%1.3f/t/t/t ARTb Vigilance\n", parameter~>brho);
                                                                                                                                                                                                                                                                                                                                                                                                                              printf("Cannot open requested parameter file.\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            (out_file, "%1.3f/t/t/t Learning rate\n", parameter->rate);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      (out_file, "%1.3f/t/t Epsilon\n", parameter->epsilon);
                                                                                                                                                           void write_param_file(parameter_struct_ptr parameter, char *filename){
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          fprintf (out_file,"%d\t\t\t Trace level\n", parameter->trace);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      parameter->display_confusion_matrix);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  (out file,"%1.3f/t/t/t 2-Bar\n", parameter->2 bar);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        fprintf (out_file,"%d\t\t\t Number ot training patterns\n",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            (out file, "%1.3f/t/t/t Alpha\n", parameter->Alpha);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              fprintf (out_file,"%d\t\t\t\umber of predict patterns\n",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     fprintf (out_file, "%d\t\t\t Number of attributes ARTa\n",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      fprintf (out_file,"%d\t\t\t Number of attributes ARTb\n",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            fprintf (out_file,"%d\t\t\t Number of data categories\n",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  Eprintf (out_file,"%1.3f\t\t\t Minimum ARTa vigilance\n",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 fprintf (out_file, "%d/t/t/t Display confusion matrix/n",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          fprintf (out_file,"%d\t\t\t Number of test_patterns\n",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       parameter->num_data_category);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            parameter->employ_weighting);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          parameter->noise tolerance);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              parameter->max iterations);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   printf("Exiting from program.\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               fprintf (out_file,"%1.3f/t/t/t Noise tolerance\n",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   parameter->predict_pats);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        parameter->train_pats);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          parameter->test_pats);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                parameter->b length);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          parameter->a_length);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             parameter->min arho);
                                                     Function: writes the parameters to a text file
                                                                                                                                                                                                                                                                                                                   out_file = fopen(filename, "w");
Routine Name : write_param_file
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         exit(1);
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(network->num_category[ARTa]
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                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     (network->num_catego
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      (network->num_categor
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     (network->num_category[ARTa]+1));
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           (network->num_category[ARTa]+1));
                                                                                                                                                                                                                                                                                         (network->num_category[ARTa]+1));
                                                                                          network->dn[i][j] =(float *) malloc(sizeof(float)*network->num_att[i]);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                               (network->num_category[ARTa]+1));
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     (network->num_category[ARTa]+1));
(network->num_category[i]+1));
                                                                                                                                                                                                                                                                                                                                                                                    (network->num_category[ARTa]+1));
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             network->F2[whichART]=(float *)realloc(network->F2[whichART], sizeof(float)*
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  network->committed[whichART] = (int *)realloc(network->committed[whichART],
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            void realloc_memory(network_data_ptr network, parameter_struct_ptr parameter,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   network->vg[whichART][network->num category[whichART]] =
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        network->vg[whichART] = (float *)realloc(network->vg[whichART],
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            int whichART)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             network->F2[whichART][network->num_category[whichART]] = 0.0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      network->committed[i] = (int *) malloc(sizeof(int)*
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   sizeof(float)*(network->num_category[whichART]+1));
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 network->first_prediction = (float *)malloc(sizeof(float)*
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 Function: Allocate new memory when a new ARTa or ARTb F2 node is
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             sizeof(int)*(network->num_category[whichART]+1));
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     network->test_accuracy = (float *)malloc(sizeof(float)*
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           network->committed = (int **) malloc(sizeof(int *)*2);
                                                   for (j=0; j<network->num_category[i]+1; j++)
                                                                                                                                                                                                                                         network->confidence = (float *)malloc(sizeof(float)*
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           network->makes_prediction=(int *)malloc(sizeof(int)*
                                                                                                                                                                                                                                                                                                                                                                                                                               network->accuracy = (float *)malloc(sizeof(float)*
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              network->target_class = (int *)malloc(sizeof(int)*
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                network->num_predict = (int *)malloc(sizeof(int)*
                                                                                                                                                                                                                                                                                                                                    network->usage = (float *)malloc(sizeof(float)*
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             (network->num_category[whichART]+1));
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      network->freeze =(int *)malloc(sizeof(int)*
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      Routine Name : Realloc_Memeory
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           for (1=0; i<2; i++)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        if (whichART --- ARTa)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            }/* end of alloc_memory */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     return(status);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       else
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          status=1;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  int i;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            (network->num_caregory[ARTb]+1));
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        (network->num_category[ARTa]+1));
for (i=0; i<network->num_category[ARTa]+1; i++)
network->nAMI[i]=(float *)malloc(sizeof(float)* (network->num_category[ARFb]
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  (network->num_category[i]+1));
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       (network->num_category[i]+1));
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        network->pattern[ARTb]=(float *)malloc(sizeof(float)*network->num_att[ARTb]);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 network->pattern[ARTa]=(float *)malloc(sizeof(float)*network->num_att[ARTa]);
                                                                                               fprintf (out_file,"%d\t\t\t Extracting rules\n", parameter->extract_rules):
fprintf (out_file,"%d\t\t\t Quantizing rules\n", parameter->quantize_rules);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             (network->num_category[ARTb]+1));
                                                                                                                                                                                                                                                                                         fprintf (out_file,"%d\t\t\t Individual vigilance\n", parameter->ind_vg);
                                                                                                                                                                                                                                                                                                                                                                                                                           fprintf (out_file,"%f\t\t Threshold\n", parameter->u_threshold);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       network->F2[i] =(float *) malloc(sizeof(float)*
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        network->vg[i] = (float *)malloc(sizeof(float)*
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    /*---
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  network->dn[i] = (float **) malloc(sizeof(float *)*
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             network->first_prediction = (float *)malloc(sizeof(float)*
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      network->pattern = (float **)malloc(sizeof(float *)*2);
                                                        parameter->incorporate_rules);
                                                                                                                                                                                                                                         parameter->quantization step);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   network->dn = (float ***)malloc(sizeof(float **)*2);
                                                                                                                                                                                                                                                                                                                                fprintf (out_file,"%d\t\t\t Number of F2 winners\n",
                                                                                                                                                                                                                                                                                                                                                                                        parameter->num F2 winners);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            network->F2 = (float **)malloc (sizeof(float *)*2);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 network->vg = (float **)malloc (sizeof(float *)*2);
    fprintf (out_file,"%d\t\t\t Incorporating rules\n",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         committed, predict, freeze, num_predict, usage, accuracy,
                                                                                                                                                                                          fprintf (out_file,"%d\t\t\t Quantization step\n",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          Function: Allocate memory for ARTMAP network, including
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     network->IAMI = (float **)malloc(sizeof(float *)*
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          weight templates, map field, vigilance, Fab activities
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     and ARTa F2 nodes activities, and attached attributes:
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  network->Fab = (float *)malloc(sizeof(float)*
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               int alloc_memory(network_data_ptr network)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           for (i=0; i<2; i++)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            for (1=0; i<2; i++)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                test accuracy and confidence.
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   Routine Name : alloc memory
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              //*end of write_param_file */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   for (1=0; 1<2; 1++) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              fclose(out_file);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      int i, j, status;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           +1));
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Filesize: 26.65 kbytes

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                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      for (j=0; j<NUM_STAGE; j++)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 series->sum_sq_rate_on_test = 0.0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            series->min rate on test = 100.0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           series->num_perfect_mismatch = 0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              series->tot_committed_nodes = 0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            series->max_committed_node = -1;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 series->max_rule_extracted = -1;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   series~>acc_num_antecedent = 0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      series->acc_rule_extracted = 0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               series->max_rate_on_test = 0.0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          series->sum_rate_on_test = 0.0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      series->tot no prediction = 0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      series->num_no_prediction = 0;
                                                                                                                                                                                        printf ("data series allocated.\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                for (j=0; j<NUM STAGE; j++)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             for(j=0; j<NUM_STAGE; j++)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       Routine Name : Free Series Data
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        series->num_right = 0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           series->num_wrong = 0;
                                                                                                                                                                                                                                                                                                                                         Routine Name : Init Series
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         int ps_x, ps_y, i, j, k, v;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      malloc(sizeof(int *) * (parameter->num_data_category+1));
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            void alloc_series_memory(series_data_ptr series, parameter_struct_ptr parameter
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               series->right_wrong(j)=(int ***)malloc(sizeof(int **) * parameter->num_voters);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               series->p_table[j][v][i] =(int *)malloc(sizeof(int) *
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      parameter->num_data_category);
                                   Printed: Thu Sep 7 09:26:00 1995
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        for (i=0; i<parameter->num_data_category+1; i++)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        series->right_wrong[j][v]=(int **)malloc(sizeof(int *)* 2);
for (i=0; i<2: i++)</pre>
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                parameter->num_voters);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         series->p_table[j] =(int ***) malloc (sizeof(int **) *
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              0, parameter->num_data_category+1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       series->p_table = (int ****)malloc(sizeof(int ***)*NUM_STAGE);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  series->sum_sq_rate= matrix(0, NUM_STAGE, 0, parameter->num_voters);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     series->right_wrong =(int ****)malloc (sizeof(int ***)*NUM_STAGE);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           series->sum_rate = matrix(0, NUM_STAGE, 0, parameter->num_voters);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  Function: Allocate memory for series data on the test patterns.
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             parameter->num_data_category);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  0, parameter->num_data_category);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   for (v=0; v < parameter->num_voters; v++) (
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               series->right_wrong[j][v][i] = (int *)malloc(sizeof(int) *
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          series->p_table[j][v] =(int **)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               0, parameter->num_voters,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       series->num votes = matrix(0,data->num pixels,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     for (v=0; v<parameter->num_voters; v++)(
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    data_struct_ptr data)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            if(parameter->display_confusion_matrix) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        series->C = f3tensor(0,NUM_STAGE,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  for (j-0; j<NUM STAGE; j++) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                           Routine Name : alloc_series_memory
                                                                                                                                                                                        free (network->committed);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            for (j=0; j<NUM_STAGE; j++) (
                                                                                                                                                                                                                                                                                                      return(status);
\frac{PAGE}{9}
                                                                                                                                                                                                                                                                  status =1;
```

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for (k=0; k<parameter->num data category; k++)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    data_struct_ptr data)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  void free_series_data(series_data_ptr series, parameter_struct_ptr parameter,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 series->right_wrong[j][v][i][k] = 0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     for(ps_x = 0: ps_x <parameter->num_data_category+1: ps_x++)
for(ps_y = 0: ps_y <parameter->num_data_category: ps_y++)
series->p_table[j][v][ps_x][ps_y] = 0:
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  series->min_committed_node = 9999; /* change to 99999 in Unix */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         series~>min rule extracted = 9999; /* change to 99999 in Unix */
                                                                                          void init_series(series_data_ptr series, parameter_struct_ptr parameter)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     /*---
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     for (v=0; v<parameter->num_voters; v++)
Function: Initialize benchmarking statistical variables.
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      for (v=0; v<parameter->num voters; v++) (
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 series->sum_sq_rate[j][v] = 0.0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     for (v=0; v<parameter->num_voters; v++)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              Function: Release memory for benchmarking statistics.
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   series->sum_rate[j][v] = 0.0;
                                                                                                                                                                                                                                                                                             series->min_times_through_training = 100;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             if(parameter->display_confusion_matrix){
                                                                                                                                                                                                                                                                                                                                     series->max_times_through_training = 0;
series->tot_times_through_training = 0;
```

series->actual_category = ivector(0, data->num_pixels);

```
data->frequency =(int *)malloc(sizeof(int)*(parameter->num_data_category+1));
data->label = ivector(0, data->num_pixels-1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 printf ("\n\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    Routine Name : weight_features
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               Routine Name : Display_Weight
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        free (data->frequency);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   printf ("\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   printf ("\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            free (data->Index);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               int j, k;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         int i;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             for (i=0; i<parameter->num_data_category+1; i++)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  free_matrix(series->sum rate, 0, NUM STAGE, 0, parameter->num voters);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  void alloc_data_memory(data_struct_ptr data, parameter_struct_ptr parameter)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           data->train_Index=(int *)malloc(sizeof(int)*(parameter->train pats+
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   0, parameter->num_data_category+1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 0, parameter->num_data_category);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               free(series->p_table[j][v][i]);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                data->dpt-matrix(0,data->num_pixels-1,0,parameter->a_length);
data->Index = (int *)malloc(sizeof(int)*data->num_pixels);
                                                                                                                                                                                                                        free(series->right_wrong[j][v][i]);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         0, parameter->num_voters);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          free_ivector(series->actual_category, 0, data->num_pixels);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          Function: Allocate memory for input patterns, Index array, label,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   0, parameter->num_voters,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        for (v=0; v<parameter->num_voters; v++) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    free(series->p_table[j][v]);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              free_matrix(series->num_votes, 0, data->num_pixels,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  and frequence information.
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            parameter->predict_pats));
                                                                                                                                                 for (v=0; v<parameter->num_voters; v++) {
                                                                                                                                                                                                                                                             free(series->right_wrong[j][v]);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       free_matrix(series->sum_sq_rate, 0, NUM_STAGE,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              free_f3tensor(series->C, 0, NUM_STAGE,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           free(series->p_table[j]);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 if(parameter->display_confusion_matrix){
                                                                                                                                                                                                                                                                                                                                free(series->right_wrong[j]);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  for (j=0; j<NUM_STAGE; j++) {
                                                                                                                                                                               for (1=0; i<2; i++)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                1f (parameter->employ_weighting) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   free(series->p_table);
                                                                                                        for (j=0; j<NUM_STAGE; j++) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        free (parameter->wt);
                                                                                                                                                                                                                                                                                                                                                                                                           free (series->right_wrong);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        Routine Name : Alloc_Data_Memory
                                 int i, j, v;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             register int i;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             A-66
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for (k=network->num att[ARTa]/2; k<network->num_att[ARTa]; k++)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               void weight_features(network_data_ptr network, parameter_struct_ptr parameter)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        void free_data_memory(data_struct_ptr data, parameter_struct_ptr parameter)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          free_matrix(data->dpt,0,data->num_pixels-1,0,parameter->a_length);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   Function: Display the learned weight templates and map field values.
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               printf ("%1.2f ", network->dn[ARTa][j][k]);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       printf ("%1.2f ", network->dn[ARTa][j][k]);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           Function: Weight the input features based on weighting factors.
                                                                                                                                                                                                                                                                                                                                                               Function: Release memory for data patterns, Index array, label,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       printf ("%1.2f ", network->IAMI[j][k]);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  network->pattern[ARTa][i] = network->pattern[ARTa][i]*
parameter->wt[i*parameter->a_length];
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       for (k=0; k<network->num_category[ARTb]; k++)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     printf ("Category %d ARTa Weight: \n", j+1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         for (k=0; k<network->num_att[ARTa]/2; k++)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              printf ("Category %d Map Field : ", j+1);
                                                                                                                                                                                                                                                                                                                                                                                                               and frequence information.
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              free_ivector(data->label,0,data->num_pixels-1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               for (j=0; j<network->num_category{ARTa}; j++){
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  for (i=0; i<network->num att[ARTa]; i++)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       void display_weight(network_data_ptr network)
printf ("data memory allocated.\n");
                                                                                                                                                                                                                                                                                                                Routine Name : Free_Data_Memory
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       free (data->train_Index);
```

Filename: imp_io.c

Last Updated: Thu Aug 31 01:16:37 1995 $PAGE_{I4}$	series_deta_ptr series) 10: (co);	Filesize: 26.65 kbytes
$egin{array}{ c c c c c c c c c c c c c c c c c c c$	Routino Name: Report train performance Routino Name of Ropert the prediction performance daring training. Function Report the prediction performance daring training performance for the prediction when the performance for the prediction of the performance of concept performance of the performance	Filename: imp io.c

Source code for the Confusion Matrix AVS module

TITIE: DATE:

Last Updated: Thu Aug 31 01:16:27 1995

 $/\star$ this is the structure to support the "truth" or "class map" image $\star/$ /* layered debug definitions */ MAP_STRUCT, *map_struct_ptr; int num_classes; int num rows; int num_cols; #define CONF_DEBUG #define MAXSTR 80 typedef struct{ #define DEBUG A-69

#include <avs/field.h>

#include <avs/flow.h>

#include "memutil.h"

/* this is the confusion matrix structure */ CONF MATRIX STRUCT, *conf matrix ptr; float weighted_accuracy; float BandP_kappa; int num classes; float accuracy; int num_rows; int num cols; int **array; float kappa; int count; typedef struct{

Filename: AVS conf matrix.c

/* function prototypes */
int confusion(AVSfield_float *truth_image,

AVSfield_float *class_image,

map_struct_ptr truth,

/* create the input port for the classification map RIGHTMOST */
class_port = AVScreate_input_port("Class Image",
 "field 2D uniform float", REQUIRED); CLASSIFIE "Classification accuracy:","",""); int write_output(char *filename, conf_matrix_ptr conf_matrix); AVSset_module_name("Confusion Matrix", MODULE_FILTER); AVSadd_parameter_prop(param,"width","integer",4); AVSadd_parameter_prop(param,"width","integer",4); /* create the input port for the truth image LEFIMOST */ AVSmodule_from_desc(AVS_confusion_matrix); param = AVSadd_parameter("title", "string", param = AVSadd_parameter("info","string", /* display truth and classified port location */ conf matrix ptr conf matrix); AVSconnect_widget(param,"text"); map_struct_ptr class_map, int AVS_confusion_matrix(); int truth_port, class_port; /* set the title for the window */ /* set the module name and type */ int compute confmat(); /* initialize the modules */ char cwd[MAXSTR]; /* interface routine */ AVS_confusion_matrix() AVSinit_modules () int param; ח, "", "");

param = AVSadd float parameter("Weighted accuracy:", 0.0, 0.0, 100.0); param = AVSadd_float_parameter("Simple accuracy:", 0.0, 0.0, 100.0); AVSadd_parameter_prop(param, "width", "integer", 2); AVSadd_parameter_prop(param, "width", "integer", 2); AVSconnect_widget(param, "typein_real"); /* create a widget for the weighted accuracy */ /* create a widget for the simple accuracy */

AVSconnect_widget(param,"text");

param = AVSadd float parameter("Kappa coefficient:", 0.0, 0.0, 100.0);
AVSadd parameter_prop(param, "width", "integer", 2);
AVSconnect_widget(param, "typein_real"); AVSconnect_widget(param, "typein_real"); $/\star$ create a widget for the kappa coefficient $\star/$

```
param=AVSadd_parameter("Output file (*.mat):","string", cwd, 0,".mat");
                                  param=AVSadd_float_parameter("B&P's kappa coefficient:", 0.0,0.0,100.0)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 param=AVSadd_parameter("Auto-generate confusion matrix","boolean",0,0,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             param=AVSadd_parameter("Calculate confusion matrix","oneshot",0,0,0);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         param = AVSadd_parameter("View all file types", "boolean",0,0,1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        float accuracy_val, weighted_accuracy_val, kappa_val, BPkappa_val;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      AVSadd_parameter_prop(param, "width", "integer", 4);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                AVSadd_parameter_prop(param, "width", "integer", 4);
                                                                                                          AVSadd_parameter_prop(param, "width", "integer", 2);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      AVSadd_parameter_prop(param, "width", "integer",4);
                                                                                                                                                                                                                                                                                                                                                                                                            AVSadd_parameter_prop(param, "width", "integer", 4);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             float *interface_weighted_accuracy,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    /\star create a widget to generate the confusion matrix ^\star/
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              This function does the confusion matrix computations
/\star create a widget for the B&P kappa coefficient \star/
                                                                                                                                                AVSconnect_widget(param, "typein_real");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      int compute_confmat(AVSfield_float *truth_image,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            AVSfield_float *class_image,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           int map_test, map_high, truth_test, truth_high;
                                                                                                                                                                                                                         /* create a widget for the output filename */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              AVSset_compute_proc(compute_confmat);
                                                                                                                                                                                                                                                                                                                                                                                                                                                     AVSconnect_widget(param, "browser");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               AVSconnect widget(param, "toggle");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     /\star set the function to create the output ^{\star}/
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              /* allow user to view all file types */
                                                                                                                                                                                                                                                                                                    if( cwd[strlen(cwd)-1] != '/')
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              float *accuracy,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     float *BPkappa,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           char *filename,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           /* create autogeneration widget */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             int all,
int auto_run,
int run)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               float *kappa,
                                                                                                                                                                                                                                                                                                                                          strcat(cwd,"/");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        char *title,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    map_struct_ptr truth, class_map;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     char *info,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       conf_matrix_ptr conf_matrix;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           function compute confmat
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  register int row, col;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              /* local variables */
                                                                                                                                                                                                                                                                  getwd(cwd);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 char *answer;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            int status;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   A-70
```

```
"Output file %s already exists.\n", filename);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                AVS VALUE, filename, 0, 0);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          AVSmodify_parameter("Output file (*.mat):",

AVS_VALUE|AVS_WAXVAL, "/tmp/", 0, ".mat");

printf( "Setting maxval to .mat\n");

AVSmodify_parameter("Output file (*.mat):",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  AVSmodify_parameter("Output file (*.mat):",
                                                                                                                                                                                                                                                                                                                                                                       AVSmodify_parameter("Output file (*.mat):",
                                                                                                                                                                                                                                                                                                            AVS VALUE | AVS MAXVAL, "/tmp/", 0, "");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       fclose(output_file);
printf("Output file already exists.\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     printf("Output file does not exist.\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        if( strcmp(answer,"Overwrite") == 0 )
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            /* see if we have a file and NOT just a directory */
                                                                                                                                                                                                                                                                                                                                           printf( "Setting maxval to null\n");
                                                                                                                                                                                                                  if(AVSparameter_changed("View all file types")){
                                                                                                                                                                                                                                                                                                                                                                                                   AVS_VALUE, filename, 0, 0);
                                                                                                                                                                                      /* check for view all parameter filenames */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           output_file = fopen(filename,"r+");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  if(filename[strlen(filename) - 1] == '/'){
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    file_status = 1;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               status = strcmp(filename, old_filename);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  file status = 0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               strcpy(old filename, filename);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    return(1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         if(output_file -- NULL) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      /* see if filename has changed */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    new file = 1;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   file_status = 0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      else {
FILE *output file;
static int file_status = 0;
static int new_file = 0;
static char *old_filename[80];
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          new_file = 0;
                                                                                                                        char *reset_filename = " ";
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  return(1);
                                                                                                                                                                                                                                                    if (all) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                if (status != 0) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           else {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                 else(
```

Filesize: 21.14 kbytes

Filename: AVS conf matrix.c

```
"Kill module", "The number of classes in the truth and classification map
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                AVSmessage("beta", AVS_Fatal, NULL, "Calculate confusion matrix", "Kill module"
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          , "The number of rows and columns in the truth and classification map do not ag
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 printf("Num classes in the class map image = %d", map_high); AVSmessage("beta", AVS_Fatal, NULL, "Create Confusion Matrix",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           printf("Num classes in the truth image = %d\n",truth->num_classes);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          (truth->num_cols != class_map->num_cols)) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               printf("Num classes in the truth image = %d", truth_high);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               printf("Num rows/columns in the class map image = %d / %d.\n",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 status = confusion(truth image, class image, truth, class map,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     truth test = (int)I2D(truth image, col, row);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       map_test = (int)I2D(class_image, col, row);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                printf("Num rows/columns in the truth image = %d / %d.\n",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            /* search both images to find the number of classes */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     printf("Num classes in the class map image = %d\n",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         class_map->num_rows, class_map->num_cols);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           for(col=0; col < truth->num_cols; col++){
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     truth_high = truth_test;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                if((truth->num_rows != class_map->num_rows) ||
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              map_high = map_test;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               if (truth test > truth high)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      truth->num_rows, truth->num_cols);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      for(row=0; row < truth->num rows; row++) {
                                                                                                                                                                                                                                                                                                                                                                               class map->num rows = MAXY(class image);
                                                                                                                                                                                                                                                                                                                                                                                                                        class_map->num_cols = MAXX(class_image);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                if (map_test > map_high)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      printf("The images are comparable.\n");
                                                                               printf("All structures allocated.\n");
                                                                                                                                                                                                                                                                                                                                     truth->num cols = MAXX(truth image);
                                                                                                                                                                                                                                                                                           truth->num rows = MAXY(truth image);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 class_map->num_classes = map_high;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       /* create the confusion matrix */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  class_map->num_classes);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       truth->num classes = truth high;
                                                                                                                                                                                                                                                      /* get the image statistics */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     if(truth_high != map_high) (
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  truth high = -1;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            map high = -1;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              do not agree.");
                                                 #ifdef DEBUG
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            #ifdef DEBUG
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       ree.");
                                                                                                                            #endif
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        #endif
                                                                                                                                                                                                                                                                                           AVSmodify_parameter("Calculate confusion matrix", AVS_VALUE, 0, 0, 0);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             printf("ERROR: unable to allocate truth structure pointer.\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  /* clear statistics parameters and the elapsed time from other runs */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    conf_matrix = (conf_matrix_ptr)malloc(sizeof(CONF_MATRIX_STRUCT));
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              printf("ERROR: unable to allocate class map pointer.\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       printf("ERROR: unable to allocate confusion pointer.\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                printf("Confusion matrix just entered the compute function.\normalfon);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 AVS_VALUE | AVS_MINVAL | AVS_MAXVAL,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              AVS_VALUE | AVS_MINVAL | AVS_MAXVAL,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    AVS_VALUE | AVS_MINVAL | AVS_MAXVAL,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               AVS_VALUE | AVS_MINVAL | AVS_MAXVAL,
if (file_status == 1) | ( new_file ==1) )
   printf("The output filename is: %s\n", filename);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      class_map = (map_struct_ptr)malloc(sizeof(MAP_STRUCT));
                                                                                                                                                                                                                                                  if( (run || auto_run) && (file_status || new_file) ) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     AVSmodify_float_parameter("B&P's kappa coefficient:",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 truth=(map_struct ptr)malloc(sizeof(MAP STRUCT));
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       AVSmodify_float_parameter("Weighted accuracy:",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      AVSmodify_float_parameter("Kappa coefficient:",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         /* reset the static variables for next time */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           AVSmodify_float_parameter("Simple accuracy:",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          0.0, 0.0, 0.0);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               0.0, 0.0, 0.0);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    0.0, 0.0, 0.0);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 0.0, 0.0, 0.0);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  strcpy(old_filename, reset_filename);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        /* allocate the structures */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      if (conf_matrix == NULL) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        if (class_map == NULL) (
                                                                                                                            return(1);
                                                                                                                                                                                                                                                                                                                                                                                                                     return(1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                return(1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           return(1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 return(1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   if (truth==NULL) (
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         file status = 0;
                                                                                                                                                                                                        /* check if run time */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               new_file = 0;
                                                                                                                                                                                                                                                                                                                                                                           else{
                                                                                   else
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          #ifdef DEBUG
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      #endif
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Last Updated: Thu Aug 31 01:16:27 1995

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computes the confusion matrix from the truth and the classification map images. Parameters in the interface are updated in main.
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             /* allocate the confusion matrix. Must store "background" (class 0) pixels ^{*}/
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         printf("ERROR: memory for confusion matrix not allocated.\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         printf("Memory for the confusion matrix allocated.\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        float *row_marginal, *row_summation, *col_marginal, *col_summation;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        float po, pe, class_contribution, element, numerator, denominator;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         0, conf_matrix->num_classes);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 /* allocate memory for the row and column marginals */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 conf_matrix->array=imatrix(0,conf_matrix->num_classes,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         row summation = vector(0, conf matrix->num_classes);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             col summation = vector(0, conf matrix->num classes);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         row marginal = vector(0, conf matrix->num classes);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 col marginal = vector(0, conf matrix->num classes);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    int status, truth_index, class_index, row_sum, col_sum;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    conf_matrix->num_classes = truth->num_classes;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        conf matrix->num rows = truth->num classes;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             conf_matrix->num_cols = truth->num_classes;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     printf("Initializing the matrices.\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  printf("Initializing the matrices.\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         /* initialize all the matrices to zero
                                                                                                                                                                                                                                                                                                                    int confusion(AVSfield float *truth image,
                                                                                                                                                                                                                                                                                                                                                    AVSfield_float *class_image,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                conf_matrix_ptr conf_matrix)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     row_step = 1.0 / truth->num_rows;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     if (conf_matrix->array == NULL) (
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 status = 0; /* assume failure */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        int sum_row_marginal, sum_col_marginal;
                                                                                                                                                                                                                                                                                                                                                                                                                                        map_struct_ptr class_map,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                float row_step, percent_done, stage;
                                                                                                                                                                                                                                                                                                                                                                                                   map_struct_ptr truth,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                conf matrix->count = 0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                float truth_value, class_value;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    register int row, col, diag;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             status = 1;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     return(1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            /* local variables */
                                                                                                                       function confusion
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 else(
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                int send val;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        #ifdef DEBUG
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 #ifdef DEBUG
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     #endif
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          #end1f
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     printf("ERROR: incorrect status returned from write_output.\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            weighted_accuracy_val, weighted_accuracy_val
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                accuracy_val, accuracy_val, accuracy_val);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               BPkappa val = 100 * conf_matrix->Bandp_kappa:
AVSmodify_float_parameter("B&P's kappa coefficient:",
AVS_VALUE | AVS_MINVAL | AVS_MAXVAL,
BPKappa_val, BPkappa_val, BPkappa_val);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  AVSmodify_float_parameter("Simple accuracy:",
AVS_VALUE | AVS_MINVAL | AVS_MAXVAL,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 AVS_VALUE | AVS_MINVAL | AVS_MAXVAL,
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 AVS_VALUE | AVS_MINVAL | AVS_MAXVAL,
                                                                                                                                                                                                                                    printf("The confusion matrix has been calculated.\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     weighted_accuracy_val = 100 * conf_matrix->weighted_accuracy;
                                                                            printf("ERROR: incorrect status from confusion.\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                            printf("%d\t", conf_matrix->array[row][col]);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     kappa_val, kappa_val, kappa_val);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 0, conf matrix->num cols);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  free_imatrix(conf_matrix->array, 0, conf_matrix->num_rows,
                                                                                                                                                                                                                                                                                                                                                                                                                                    for(col=0; col <= conf_matrix->num_cols; col++)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    /* update the parameters to display the results */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         weighted_accuracy_val);
                                                                                                                                                                                                                                                                                                                                                                                            for(row=0; row <= conf_matrix->num_rows; row++) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     AVSmodify_float_parameter("Kappa coefficient:",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             AVSmodify_float_parameter("Weighted accuracy:",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  status = write_output(filename, conf_matrix);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 accuracy_val = 100 * conf_matrix->accuracy;
                                                                                                                                                                                                                                                                                                                                                        printf("This is the confusion matrix:\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 /* write the results to a disk file */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 kappa_val = 100 * conf_matrix->kappa;
                                                                                                                                                                                                                                                                                                                    /* print the conf matrix to stdout */
conf_matrix);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          /* free all allocated memory */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      /* indicate success and jam */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                printf("\n");
                                                                                                                    return(1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             return(1);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              free(conf_matrix);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 if(status != 1){
                                       if(status != 1) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          free(class_map);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  free (truth);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  } /* end of main */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              return(1);
                                                                                                                                                                                            else
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Last Updated: Thu Aug 31 01:16:27 1995

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AVSmessage ("beta", AVS_Fatal, NULL, "Calculate confusion matrix", "Kill module
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         printf("Row/column marginals and total pixel count agree. \n");
                                                                                                                                                                 row_marginal(row) = (float)row_sum/(float)conf_matrix->count;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              col_marginal[col] = (float)col_sum/(float)conf_matrix->count;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   /* the sum of either the row marginals or the column marginals must
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     ","The row and column marginals of the confusion matrix do not agree.");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 #ifdef CONF_DEBUG /* Debug code to echo the row and column marginals */
                                                                              for(col=0; col <= conf_matrix->num_classes; col++)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                for(row=0; row <= conf_matrix->num_classes; row++)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 element = (float)conf_matrix->array[diag][diag];
                                                                                                                        row_sum += conf_matrix->array[row][col];
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         col_sum += conf_matrix->array[row][col];
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            for(diag=0; diag <= conf_matrix->num_classes; diag++) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         (sum_row_marginal != conf_matrix->count) ||
(sum_col_marginal != conf_matrix->count)) {
                                                                                                                                                                                                                                                                                                                                                                                                                 for(col=0; col <= conf matrix->num_classes; col++)(
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 printf("Calculating the accuracy measurements.\n");
       for(row=0; row <= conf_matrix->num_classes; row++) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            /* calculate the simple accuracy and po and pe ^{\star}/
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 for (row=0; row <= conf_matrix->num_rows; row++)
printf("%f\t", col_summation[row]);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                for (row=0; row <= conf_matrix->num_rows; row++)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 for (row=0; row <= conf_matrix->num_rows; row++)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               for (row=0; row <= conf_matrix->num_rows; row++)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   printf("These are the column summations.\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       if((sum row marginal != sum_col_marginal) ||
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        col_summation[col] = (float)col_sum;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            printf("These are the column marginals.\n");
                                                                                                                                                                                                      row_summation[row] = (float)row_sum;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      printf("These are the row summations.\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    printf("%f\t",row_summation[row]);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           printf("These are the row marginals.\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         printf("%f\t",row_marginal[row]);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       printf("%f\t", col_marginal[row]);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    conf_matrix->weighted_accuracy = 0.0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             sum_col_marginal += col_sum;
                                                                                                                                                                                                                                                sum_row_marginal += row_sum;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            equal the total number of pixels */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       conf_matrix->accuracy = 0.0;
                                                                                                                                                                                                                                                                                                                                                                           sum col marginal = 0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                              col sum = 0;
                                                row_sum = 0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      printf("\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                printf("\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          printf("\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       printf("\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             po = 0.0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  pe = 0.0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           else
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 #endif
                                                                                                                                                                                                                                                                                                                                                                                                                 /* step through images, create the confusion matrix, and count all pixels */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              conf_matrix->array[class_index][truth_index] += 1;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   printf("Incrementing element [%d][%d] of the confusion matrix.\n"
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            AVSmodule_status("percent complete", send_val);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          printf("The total number of pixels = %d\n",conf_matrix->count);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  /\star calculate the row/column marginals and their summation \star/
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  printf("%d\t", conf_matrix->array[row][col]);
for(row=0; row <= conf_matrix->num_classes; row++){
   for(col=0; col <= conf_matrix->num_classes; col++){
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         for (col = 0; col <= conf_matrix->num_cols; col++)
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            truth_value = I2D(truth_image, col, row);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              class_value = 12D(class_image, col, row);
truth_index = (int)truth_value;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      printf("percent complete %d\n", send_val);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       percent_done = (float)row/(float)truth->num_rows;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            printf("Calculating the row and column marginals.\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           (percent_done < stage + (2 * row_step)) ) (
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      for(col=0; col < truth->num_cols; col++) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    for (row=0; row <= conf_matrix->num_rows; row++) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 send_val = (int) (100.0 * stage);
                                                                                          conf_matrix->array[row][col]=0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                class index = (int)class value;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     printf("Calculating the confusion matrix.\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              /* report the level of completion */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              printf("This is the confusion matrix.\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 for(row=0; row < truth->num_rows; row++) {
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    conf_matrix->count+=1;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               /* end of col loop */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  if (percent_done > stage) &&
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            class_index,truth_index);
                                                                                                                                                                                                                                                                                         col_summation[row] = 0.0;
                                                                                                                                                                                                          col_marginal[row] = 0.0;
                                                                                                                                                                                                                                                row_summation[row] = 0.0;
                                                                                                                                                                     row_marginal[row] = 0.0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         stage += 0.10;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      /* end of row loop */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       /* end if */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            printf("\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     sum row marginal=0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        stage = 0.10;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             #ifdef CONF_DEBUG
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         #ifdef CONF_DEBUG
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                #ifdef DEBUG
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              #endif
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    #endif
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     #endif
```

Filename: AVS conf matrix.c

Printed: Thu Sep 7 09:30:00 1995

Last Updated: Thu Aug 31 01:16:27 1995

RAGE

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fclose(out_file); printf("The confusion matrix file was successfully written to disk.\n");
                                                                                                                                                                                                                                                            fprintf(out_file,"%d\t",conf_matrix->array[row][col]);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     fprintf(out_file,"The simple accuracy = %f\n",conf_matrix->accuracy);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 fprintf(out_file, "The kappa coefficient = %f\n", conf_matrix->kappa);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             fprintf(out_file, "Brennan and Prediger's kappa coefficient = %f\n",
                                                                                                                                                                                                            for(col=0; col <= conf_matrix->num_cols; col++)
                                                                                /* print the confusion matrix */
fprintf(out_file,"This is the confusion matrix:\n");
for(row=0; row <= conf_matrix->num_rows; row++){
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 fprintf(out file, "The weighted accuracy = %f\n",
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         conf_matrix->BandP_kappa);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             conf matrix->weighted accuracy);
                                                                                                                                                                                                                                                                                                                                                                                                                                         /* print the accuracy measurements */
                                                                                                                                                                                                                                                                                                        fprintf(out_file,"\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          /* end of write_output */
rewind (out_file);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      return(status);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           this function writes the confusion amtrix and the accuracy measurements
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                **********************
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          printf("The kappa coefficient = %f\n", conf_matrix->kappa);
printf("B and P's kappa coefficient = %f\n", conf_matrix->BandP_kappa);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                to a user defined disk file. The function will happily cream any disk
                                                                                                                                                                                                                                                                conf_matrix->weighted_accuracy /=(float)conf_matrix->num_classes+1;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             denominator = 1.0 - (1.0/(float)(conf_matrix->num_classes+1));
                                                conf_matrix->weighted_accuracy += class_contribution;
    class_contribution = element / col_summation[diag];
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          printf("The simple accuracy = %f\n", conf_matrix->accuracy);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             numerator = po-(1.0/(float)(conf_matrix->num_classes+1));
                                                                                                                                pe += row_marginal[diag] * col_marginal[diag];
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      free_vector(row_marginal,0,conf_matrix->num_classes);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              free_vector(col_marginal,0,conf_matrix->num_classes);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    int write_output(char *filename, conf_matrix_ptr conf_matrix)
                                                                                                                                                                                                                                                                                                                                                                                                                                             printf("Calculating the kappa measurements.\n");
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     conf_matrix->BandP_kappa=numerator/denominator;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         CONF_DEBUG /* Debug code to echo the accuracy */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            file with the same name as the user inputs
                                                                                                                                                                                                                                                                                                                                                                                            /* calculate both kappa measurements */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 printf("The value of po is %f\n",po);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              printf("The value of pe is %f\n",pe);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         conf_matrix->kappa=(po-pe)/(1.0-pe);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             /* assume failure */
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 out_file = fopen(filename, "w");
                                                                                                                                                                                                                    po /= (float)conf_matrix->count;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              /* free the allocated memory */
                                                                                                                                                                                                                                                                                                            conf_matrix->accuracy = po;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       } /* end of compute_conf_matrix */
                                                                                            po += element;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               Function write_output
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       return(status);
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 register int row, col;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 status=0;
                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    FILE *out file;
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Filesize: 21.14 kbytes

Filename: AVS conf matrix.c

AVSmessage("beta", AVS_Error, NULL, "Confusion matrix", "Okay", "Could not or

eate the confusion file: \n%s", filename);

return(1);

if(out_file == NULL)(

A-74

Task 1 Confusion Matrices

Last Updated: Tue Aug 29 20:24:40 1995 PAGE 2		Filesize: 0.35 kbytes
$rac{PAGE}{I}$ Printed: Thu Sep 7 15:54:52 1995	### 1	Filename: tfca_city_6c9m88r.mat

Last Updated: Tue Aug 29 20:24:40 1995 PAGE 2		Filesize: 0.35 kbytes
$egin{array}{c c} PAGE & ext{Printed: Mon Sep 11 11:51:11 1995} \end{array}$	This is the confusion matrix: 11858	Filename: tfcg_city_6c9m256c.mat

Last Updated: Tue Aug 29 20:24:40 1995		Filesize: 0.36 kbytes
$egin{array}{c c} PAGE & Printed: Thu Sep 7 16:01:12 1995 & & & & & & & & & & & & & & & & & & $	This is the confusion matrix; 126 6 2 944 6311 117 3807 323 21 12126 0 0 0 1 0 0 4128 0 3312 1731 5630 0 0 6991 0 345 3104 0 0 3111 0 2669 0 375 0 21789 0 6603 13 2669 0 305 0 1892 41248 The wighted accuracy 0.787533 The wighted accuracy 0.787533 The wighted accuracy 0.775349 The wighted accuracy 0.775448 The wighted accuracy 0.775448 The wighted accuracy 0.775448	Filename: tfcn_city_c14.mat

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Printed: Thu Sep 7 16:03:14 1995	3 66738 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	8
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ā	atrix: 236 0 0 6 6 1748 0 0 2 2 0 6 2 2 0 6 2 2 2 0 6 2 2 2 0 6 2 2 2 0 6 2 2 2 0 6 2 2 2 2	ğ
	This is the confusion matrix: 1122	Filename: ttca_landcover_6c9m905r.mat
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Last Updated: Tue Aug 29 20:24:40 1995 PAGE 2		Filesize: 0.39 kbytes
$PAGE \ Printed$: Thu Sep 7 16:03:47 1995	This is the confusion matrix: 33	Filename: tfcg_landcover_6c9m350c.mat

Last Updated: Tue Aug 29 20:24:40 1995		Filesize: 0.37 kbytes
$egin{array}{c c} PAGE & Printed: Thu Sep 7 16:04:08 1995 & & & & & & & & & & & & & & & & & & $	This is the confusion matrix: 111	Filename: tfcn_landcover_c14.mat

Last Updated: Tue Aug 29 20:24:40 1995 $\frac{PAGE}{2}$		Filesize: 0.29 kbytes
PAGE Printed: Thu Sep 7 16:04:44 1995	1381 1650 00 Nusion matrix 1251 1850 00 1850 0	Filename: tfca_roch84_5c85m9r.mat

Last Updated: Tue Aug 29 20:24:40 1995		Filesize: 0.32 kbytes
$egin{array}{c c} PAGE & Printed: Thu Sep 7 16:05:20 1995 & & & & & & & & & & & & & & & & & & $	### ### ### ### #### #### #### ########	Filename: tfcg_roch84_5c85m160c.mat

Last Updated: Tue Aug 29 20:24:40 1995 $\frac{PAGE}{2}$		Filesize: 0.34 kbytes
PAGE Printed: Thu Sep 7 16:05:57 1995	This is the confusion matrix: 1135	Filename: tfcn_roch84c12v2.mat

Last Updated: Tue Aug 29 20:24:40 1995			Filesize: 0.31 kbytes
$\left egin{array}{c} PAGE \ I \end{array} ight $ Printed: Thu Sep 7 16:06:53 1995	This is the confusion matrix: 6510 965 2050 0 1488 2544 0 115959 9 0 0 0 0 0 149 29048 0 311 0 4101 0 0 2116 0 1475 0 0 0 1093 0 39460 2737 0 0 0 0 207 39778 The simple accuracy = 0.931484 The weighted accuracy = 0.885425 The Kappa coefficient = 0.903023 Brennan and Prediger's Kappa coefficient = 0.917781		Filename: tfca_seashore_5c85m9r.mat

Last Updated: Tue Aug 29 20:24:40 1995 2		Filesize: 0.33 kbytes
Printed: Thu Sep 7 16:07:18 1995		n145c.mat
: Thu Sep	2 1826 214 28 8 15 3229 32978 cient = 0.853485	Filename: tfcg_seashore_5c85m145c.mat
Printed	118 114 2726 231 2332 1826 48 113348 1742 271 345 214 5 1 29370 29 43 28 2	tfcg_seas
PAGE	1114 2726 521 48 113348 1742 271 7 31 29370 29 26 48 82 7227 2 4 3749 91 18 31 49 6736 The simple accuracy = 0.877904 The weighted accuracy = 0.877904 The kappa coefficient = 0.8292 Brennan and Prediger's kappa c	Filename:
	3 3 3 3 4 4 8 3 3 4 4 8 3 4 4 8 3 4 4 8 3 4 4 8 4 8	

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Printed: Thu Sep 7 16:07:34 1995	2645 4345 0 0 4632 0 31603 2352 3 37958 1 4 efficient = 0.827930	Filename: tfcn_seashore_c13.mat
$\left[egin{array}{c} PAGE & { m Print} \end{array} ight]$	This is the confusion matrix: 2624 69 2882 992 2645 4345 320 113625 2023 0 0 0 479 0 0 0 479 0 0 0 355 0 31603 2352 1996 0 0 28 3 37958 The simple accuracy = 0.856608 The waighted accuracy = 0.77211 The kappa coefficient = 0.799434 Brennan and Prediger's kappa coefficient = 0.827930	ime: tfcn_se
$\frac{pAC}{I}$	This is the 2624 69 320 1136 731 479 0 8980 0 1996 0 The simple a The Weighted The Mergha co Brennan and	Filena

Task 2 Confusion Matrices

Last Updated: Tue Aug 29 20:24:40 1995 2		kbytes
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0:37 1995		
Printed: Thu Sep 7 16:10:37 1995	c: 3	Filename: tfcha_seg_landcover.mat
$egin{array}{c c} PAGE & Pri \end{array}$	This is the confusion matrix: 286600 3 213 0 324 0 205 0 45748 2238 2058 0 615 0 1181 49080 0 0 0 7646 0 1191 966 0 8774 The simple accuracy = 0.951852 The wabignized accuracy = 0.951852 The Aappa coefficient = 0.91734 Brennan and Prediger's kappa coefficient = 0.942223	Filename: tfcha

Last Updated: Tue Aug 29 20:24:40 1995 $\frac{PAGE}{2}$		Filesize: 0.31 kbytes
$oxed{PAGE}$ Printed: Thu Sep 7 16:10:55 1995	1862 as the contunion matrix: 1862 as 1871 6 0 0 4 12 3328 0 2 2000 11017 6210 2685 2334 0 4301 0 5391 822 211 3 2 4878 811 Pre weightes coursey = 0.85331 The weightes coursey = 0.85331 The kapa coefficient = 0.8707070 Browns and Preediger's kappa coefficient = 0.907821	Filename: tfchgml_seg_landcover.mat

Last Updated: Tue Aug 29 20:24:40 1995 PAGE 2		Filesize: 0.28 kbytes
$\frac{PAGE}{I}$ Printed: Thu Sep 7 16:11:30 1995	This is the confusion matrix: 156113 6 2122	Filename: tfcha_city_water.mat

Last Updated: Tue Aug 29 20:24:40 1995 $PAGE_2$		Filesize: 0.29 kbytes
PAGE Printed: Thu Sep 716:11:41 1995	### 15 the contracton matrix: ### 22:00	Filename: tfchgml_city_water.mat

Task 3 Confusion Matrices

Last Updated: Tue Aug 29 20:24:40 1995		Filesize: 0.28 kbytes
$PAGE \mid ext{Printed: Thu Sep 7 16:13:15 1995} \mid ext{PAGE} \mid ext{Printed: Thu Sep 7 16:13:15 1995} \mid ext{PAGE} \mid ext{$	This is the confusion matrix: 405060 0 0 0 0 0 0 5572 0 0 0 0 0 1 104 3515 2 7 14 12 0 8 2010 0 5 0 0 9 1245 1 0 0 6 134 3 466 The simple accuracy = 0.99263 The wighted accuracy = 0.97681 The Kappa coefficient = 0.988009 Brennan and Prediger's Kappa coefficient = 0.999116	Filename: tuca_user_city.mat

Last Updated: Tue Aug 29 20;24:40 1995 $PAGE$		Filesize: 0.28 kbytes
$oxedsymbol{PAGE}_{I}$ Printed: Thu Sep 7 16:13:27 1995	405060 05 551 51 0 0 0 0 0 0 0 0 0 0 0 0 0 0	Filename: tucg_user_city.mat

Last Updated: Tue Aug 29 20:24:41 1995 $\frac{PAGE}{2}$		Filesize: 0.29 kbytes
$egin{align*} PAGE & Printed: Thu Sep 716:13:42 1995 & & & & & & & & & & & & & & & & & & $	This is the confusion matrix: 405060 0 0 0 0 0 5572 0 0 0 0 363 0 2408 1 573 298 85 0 1 1915 0 34 62 0 8 0 1182 5 69 0 15 0 99538 The simple accuracy = 0.977196 The kappa coefficient = 0.995630 Brennan and Prediger's kappa coefficient = 0.995630	Filename: tucn_user_city.mat

Last Updated: Tue Aug 29 20:24:40 1995		Filesize: 0.26 kbytes
This is the confusion matrix: 450664 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	D 22	Filename: tuca_user_landcover.mat

Last Updated: Tue Aug 29 20:24:40 1995 2		Filesize: 0.26 kbytes
$PAGE \ Printed:$ Thu Sep 716:14:14 1995	This is the confusion matrix: 450664 0 0 0 0 2 8890 0 223 0 95 3 4623 0 0 122 19 0 2722 0 0 0 6513 The simple accuracy = 0.999021 The weighted accuracy = 0.984265 The kappa coefficient = 0.988632 Brennan and Prediger's kappa coefficient = 0.998776	Filename: tucg_user_landcover.mat

Last Updated: Tue Aug 29 20:24:40 1995 2			Filesize: 0.26 kbytes
$egin{align*} PAGE \ I \end{array}$ Printed: Thu Sep 7 16:14:30 1995	This is the confusion matrix: 450664 0 0 0 0 0 0 425 7667 6 1017 0 64 37 4598 21 1 99 33 0 2811 0 7he simple accuracy = 0.996299 The weighted accuracy = 0.942877 The kappa coefficient = 0.96399 Brennan and Prediger's kappa coefficient = 0.995373		Filename: tucn_user_landcover.mat

Last Updated: Tue Aug 29 20:24:40 1995		Filesize: 0.23 kbytes
$egin{array}{c c} PAGE & Printed: Thu Sep. 7 16:14:43 1995 & & & & & & & & & & & & & & & & & & $	This is the confusion matrix: 255153 0 0 0 0 0 0 0 0 12 1791 8 0 28 14 825 The simple accuracy = 0.998913 The weighted accuracy = 0.958746 The kappa coefficient = 0.979214 Brennan and Prediger's kappa coefficient = 0.998550	Filename: tuca_user_roch84.mat

Last Updated: Tue Aug 29 20:24:41 1995			Filesize: 0.23 kbytes
$egin{array}{c c} PAGE & Printed: Thu Sep 7 16:14:55 1995 & & & & & & & & & & & & & & & & & & $	This is the confusion matrix: 255153 0 0 0 12 4257 16 28 0 150 1661 0 14 19 3 831 The simple accuracy = 0.999077 The weighted accuracy = 0.97452 The kappa coefficient = 0.98214 Brennan and Prediger's kappa coefficient = 0.998769		Filename: tucg_user_roch84.mat

Last Updated: Tue Aug 29 20:24;41 1995 $\frac{PAGE}{2}$				Filesize: 0.23 kbytes
$egin{array}{c c} PAGE & Printed: Thu Sep 7 16:15:08 1995 & & & & & & & & & & & & & & & & & & $	This is the confusion matrix: 255153 0 0 0 86 4184 41 2 52 59 1700 0 72 15 7 1700 0 73 1700 10 74 20 15 7 1700 10 75 1700			Filename: tucn_user_roch84.mat

PAGE 2		
Last Updated: Tue Aug 29 20:24:40 1995		bytes
Last Updated:		Filesize: 0.28 kbytes
7 16:15:21 1995		e.mat
E Printed: Thu Sep 7 16:15:21 1995	1711s is the confusion matrix: 1	Filename: tuca_user_seashore.mat
PAGE 1	This is the c 237762 0 6328 0 0 0 5 0 0 1 0 0 The weighted The kappa coe Brennan and P	Filena

Last Updated: Tue Aug 29 20:24:40 1995			Filesize: 0.28 kbytes
PAGE Printed: Thu Sep 7 16:15:40 1995	This is the confusion matrix: 237762 0 0 0 0 0 0 0 0 0 0 1 0 3541 1 1 11 0 2 0 14 1367 153 0 2 0 7 0 509 11 The simple accuracy = 0.999112 The weighted accuracy = 0.990614 Brennan and Prediger's kappa coefficient = 0.998934		Filename: tucg_user_seashore.mat

Last Updated: Tue Aug 29 20:24:40 1995 $\frac{PAGE}{2}$			Filesize: 0.28 kbytes
PAGE Printed: Thu Sep 7 16:16:54 1995	This is the confusion matrix: 237762 0 0 0 0 0 6328 0 0 0 0 0 3366 13 65 13 60 0 4 1401 71 0 86 0 85 7 369 2 1 0 2 0 0 268 The weighted accuracy = 0.997976 The kappa coefficient = 0.997571 Brennan and Prediger's kappa coefficient = 0.997571		Filename: tucn_user_seashore.mat

Plots of classification accuracy metrics

Comparison of accuracy measurements

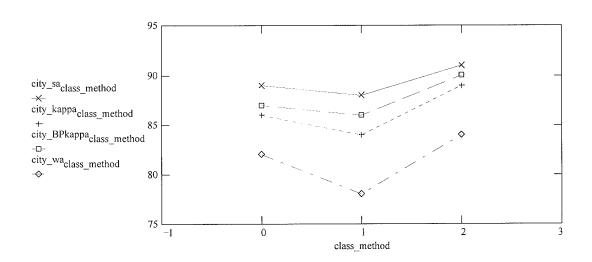
$$0 = GML$$
 $1 = nPDF$ $2 = ARTMAP$ class_method = $0, 1...2$

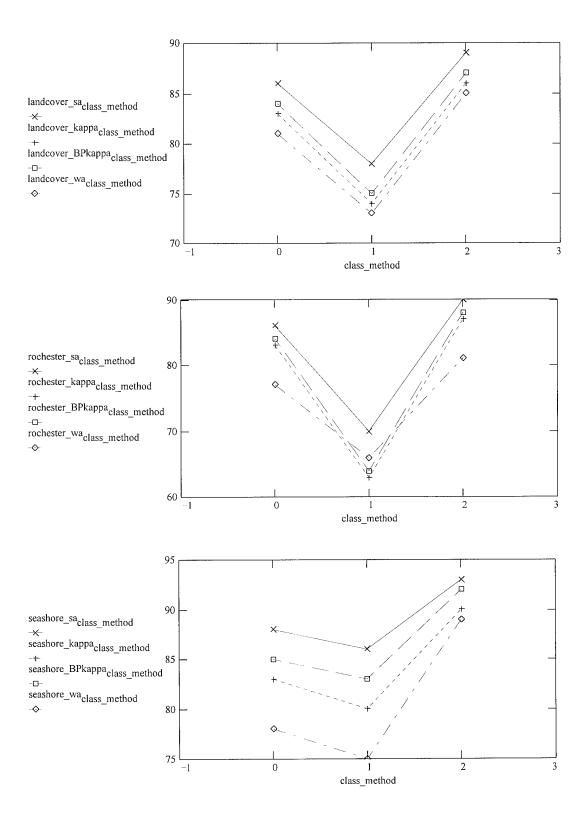
city_sa :=
$$\begin{pmatrix} 89 \\ 88 \\ 91 \end{pmatrix}$$
 landcover_sa := $\begin{pmatrix} 86 \\ 78 \\ 89 \end{pmatrix}$ rochester_sa := $\begin{pmatrix} 86 \\ 70 \\ 90 \end{pmatrix}$ seashore_sa := $\begin{pmatrix} 88 \\ 86 \\ 93 \end{pmatrix}$

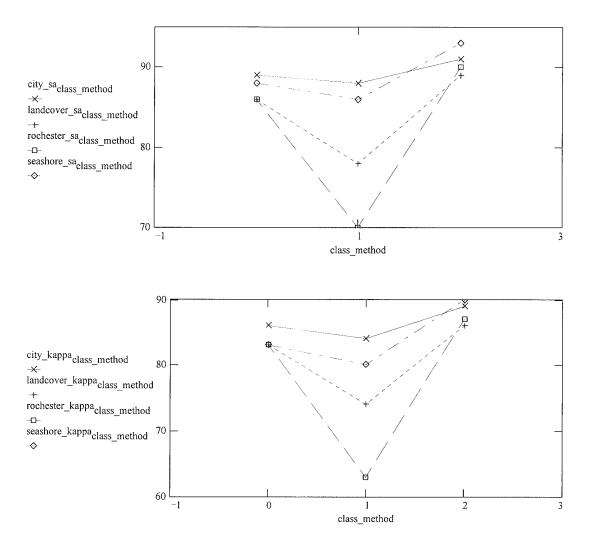
city_kappa :=
$$\begin{pmatrix} 86 \\ 84 \\ 89 \end{pmatrix}$$
 landcover_kappa := $\begin{pmatrix} 83 \\ 74 \\ 86 \end{pmatrix}$ rochester_kappa := $\begin{pmatrix} 83 \\ 63 \\ 87 \end{pmatrix}$ seashore_kappa := $\begin{pmatrix} 83 \\ 80 \\ 90 \end{pmatrix}$

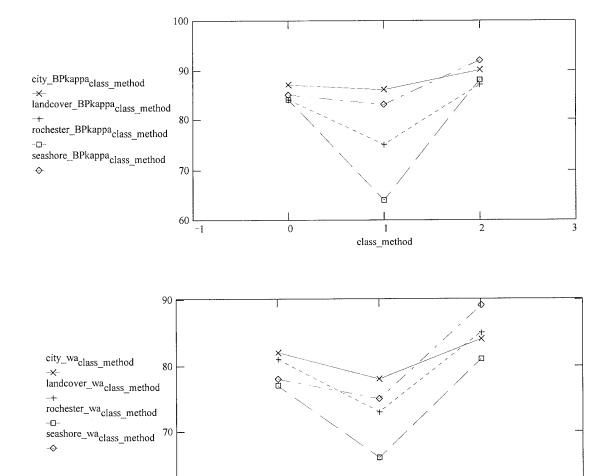
$$city_BPkappa := \begin{pmatrix} 87 \\ 86 \\ 90 \end{pmatrix} \quad landcover_BPkappa := \begin{pmatrix} 84 \\ 75 \\ 87 \end{pmatrix} \quad rochester_BPkappa := \begin{pmatrix} 84 \\ 64 \\ 88 \end{pmatrix} \quad seashore_BPkappa := \begin{pmatrix} 85 \\ 83 \\ 92 \end{pmatrix}$$

$$city_wa := \begin{pmatrix} 82 \\ 78 \\ 84 \end{pmatrix} \qquad landcover_wa := \begin{pmatrix} 81 \\ 73 \\ 85 \end{pmatrix} \qquad rochester_wa := \begin{pmatrix} 77 \\ 66 \\ 81 \end{pmatrix} \qquad seashore_wa := \begin{pmatrix} 78 \\ 75 \\ 89 \end{pmatrix}$$









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class_method